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ENGINEERING:

An Illustrated Weekly Journal.

EDITED BY WILLIAM H. MAW AND B. ALFRED RAWORTH.

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VOL. CIII.—No. 2674.] *LONDON: FRIDAY, MARCH 30, 1917.* [*Registered at the General Post Office as a Newspaper.*] PRICE 6d. BY INLAND POST 10d.

Aveling & Porter, Ltd., ROCHESTER, KENT, and 72, CANNON STREET, LONDON. STEAM ROLLERS. ROAD LOCOMOTIVES. STEAM CULTIVATING MACHINERY. STEAM WAGONS. TRACTORS. CEMENT-MAKING MACHINERY. 1288

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Locomotives Tank Engines designed and constructed by MANNING, WARDLE AND COMPANY, LIMITED, Boyne Engine Works, Leeds. Oct 2467 See their Illus. Advertisement page 103, last week.

Cochran MULTITUBULAR AND CROSS-TUBE TYPES. Boilers. See page 92, March 23. 5734

Punch and Shear Machine SPECIALISTS. 4784 Consult us. "The Best and the Cheapest." Large Stock. Satisfaction Guaranteed. Established 1860. SCOTT BROS., WEST MOUNT, HALIFAX.

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Tubes, Iron and Steel. Edwin Lewis & Sons, 5423 London Office: 142, Cannon St., E.C. Wolverhampton.

Tubes and Fittings. — Stewarts and Lloyds, Ltd., Glasgow and Birmingham. See Advertisement page 58. 5707

Several Generating Sets for SALE from 100 KW. to 800 KW., D.C. and A.C., usual voltages. 300 KW. GENERATING SET, enclosed High Speed Engine, two phase, 50 periods, 2,300 volts. 52 HP. MOTOR, three phase, 500 r.p.m. JENNINGS, West Walls, Newcastle-on-Tyne. 5355

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Machine Tools in Stock:— Vertical DRILLS, to admit 12 in., 26 in., and 36 in. diameter. Bolt Screwing MACHINES, 10½ in. centre Special Shafting LATHE. Second-hand PLANER, 25 ft. by 6 ft. by 6 ft. JAMES SPENCER & CO., LTD., 4260 Chamber Iron Works, Hollinwood, Manchester.

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Dish End Boilers,	26 ft. by 9 ft. 3 in.	150 w.p.
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" " "	24 ft. by 6 ft. 6 in.	120 w.p.

Other sizes and pressures. John Thompson, WOLVERHAMPTON. 5656

Dredging Plant OF ALL DESCRIPTIONS. FLOATING CRANES. COAL BUNKERING VESSELS. 5634 Werf Conrad, HAARLEM, HOLLAND. Agents: MARINE WORKS, LTD., FRIARS HOUSE, 39-41, NEW BROAD ST., LONDON, E.C. *See half-page Advertisement, last and next week.*

Royles Limited ENGINEERS, IRLAM, MANCHESTER. FEED WATER HEATERS, CALORIFIERS, EVAPORATORS, CONDENSERS, AIR HEATERS. (Row's Patent.) STEAM AND GAS KETTLES. Merrill's Patent TWIN STRAINERS for Pump Suctions. SYPHONIA STEAM TRAPS. REDUCING VALVES. High-class GUNMETAL STEAM FITTINGS. WATER SOFTENING and FILTERING. 5729

Yarrow Patent Water-tube Boilers. 4265 MESSRS. YARROW & CO., UNDERTAKE the PRESSING and MACHINING of the various parts of Yarrow Boilers, such as the Steam Drums, Water Pockets, and Superheaters for British and Foreign Firms not having the necessary facilities. YARROW & CO., LTD., SCOTSTOUN, GLASGOW.

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Matthew Paul & Co., Ltd. LEVENFORD WORKS, Dumbarton. 4854 See Full Page Advt., page 52, March 9.

Forgings. Walter Somers & Co., Ltd., HALESOWEN.

Head, Wrightson & Co., LIMITED. See Advertisement page 40, March 16. 5402

Taylor & Challen Presses. 5130

Railway Switches and Crossings. T. SUMMERSON & SONS, LIMITED, DARLINGTON. 5440

Coke, Gas and Oil Fired FURNACES 4334 MONOMETER MANUFACTURING CO., LTD., ASTON, BIRMINGHAM. See Advertisement page 56, March 16.

Gas Engines, Suction Plants, Inspections, Tests and Reports. Expert advice.—E. J. DAVIS, M.I. Mech. E., Great Eastern Road, Stratford. Telephones: East 1850; Stratford 809. Tel.: Rapidating, London. 1744

Aluminium. THE BRITISH ALUMINIUM CO., LTD., 109, Queen Victoria St., E.C.

CHANTIERS & ATELIERS Augustin-Normand 97, rue de Paris—LE HAVRE (France.) 2060 Destroyers, Torpedo Boats, Yachts and Fast Boats. Submarine and Submersible Boats. NORMAND'S Patent Water-tube Boilers, Coal or Oil Heating. Diesel Oil Engines.

Centrifugals. Pott, Cassels & Williamson, MOTHERWELL, SCOTLAND. 5460 See half-page Advertisement page 66, March 23.

The Manchester Steam Users' ASSOCIATION.

For the Prevention of Steam Boiler Explosions and for the Attainment of Economy in the Application of Steam. 9, MOUNT STREET, MANCHESTER.

Chief Engineer: C. E. STROMEYER, M.I.C.E.

Founded 1854 by Sir W. FAIRBAIRN.

Certificates of Safety issued under the Factory and Workshops Acts, 1901. Compensation for Damages and Liabilities paid in case of Explosions. Engines and Boilers inspected during construction. 5884

TENDERS.

In the matter of the Supply of Raw and Partly Finished Material for Ministry of Munitions' Contract for Lorries, No. 94/MT/1509, BRITISH BERNA MOTOR LORRIES, LIMITED, invite

Tenders for the Supply of the

whole or any one item of the following:—

ITEM No. 1.

Channels and Angles for 200 Lorries, as per following list:—

Pieces per Chassis.	Length req'd in m/m.	Shape in Inches.	Lbs. per foot.
2.	5500	[5 in. by 2.344 in. ...	11.5
1.	900	Ditto	Do.
2.	3080	L3 in. by 3 in., if not available than— [4 in. by 1.737 in. ...	7.25
2.	900	[4 in. by 1.737 in. ...	7.25
—	650	L6 in. by 6 in. by ⅝ in.	20
4.	2280	2½ in. by 1⅛ in. ...	3.8
1.	1000	3½ in. by ⅜ in.	7

ITEM No. 2.

4 Tons Lead-coated Sheets, 3000 m/m by 1000 m/m by 0·9 to 1·1 m/m.

ITEM No. 3.

200 Crankshafts in Chrome Nickel Steel, as per drawing to be supplied.

ITEM No. 4.

Solid drawn Steel Tubes.

35 outside by 25 m/m inside diameter;		1400 ft.
40 ,, by 30 m/m ,, ,,		800 ft.
50 ,, by 38 m/m ,, ,,		1003 ft.
60 ,, by 50 m/m ,, ,,		108 ft.

1-ton Seamless Hexagon Tubes equally divided over sizes: 19/14, 21/16, 26/20, 31/26, 36/30, 41/36, 46/40, 51/45 m/m. outside and inside over flats.

ITEM No. 5.

	Outside.	Inside.
6-cwt. Copper Tubes	6 m/m by 6 m/m	diameter.
2-cwt. ,, ,,	25 m/m by 23 m/m	,,
1-cwt. ,, ,,	65 m/m by 33 m/m	,,

ITEM No. 6.

20 tons of Steel for Bolts and Nuts in equal weights:—

(a) In round bars—60, 70, 60, 50, 40, 30 m/m.

(b) In hexagon bars—40, 35, 32, 30, 28, 25, 22, 20, 18 and 16 m/m over flats.

ITEM No. 7.

400 Front Springs, as per drawing No. 2495.
400 Rear Springs, as per drawing No. 2492.

ITEM No. 8.

200 sets of Small Stamp Forgings, 87 to a set.

ITEM No. 9.

10 tons Brass Strips—135 m/m by 0·14 m/m by not less than 40 to 50 metres long.

ITEM No. 10.

100 tons of Hematite, suitable for making Malleable Iron and Mild Steel Castings.

ITEM No. 11.

25 tons of Cylinder Iron.
25 tons of Flywheel Iron.

ITEM No. 12.

2 tons of Tin in Ingots.
2 tons of Copper in Ingots.

DELIVERY will be controlled by the Ministry—(offers in the meantime are to be based on Class A.P.4 Priority)—to be divided equally over six months where practicable and consigned in 14 day batches.

PAYMENTS. Cash on Inspectors' report and Railway Receipts.

PACKING. Where necessary for export to be included and specified in Tender.

ACCEPTANCE. Will be within seven days, but Company not bound to accept lowest or any Tenders.

TENDERS in sealed envelopes addressed to—

ALEX. D. BARTY, M.I. Mech. E.,
BRITISH BERNA MOTOR LORRIES, Ltd.,
Avonmore Road,
West Kensington, W.14.

by Twelve Noon Thursday (12th April, 1917). G 477

IN THE MATTER OF THE TRADING WITH THE ENEMY AMENDMENT ACT, 1916.

The PUBLIC TRUSTEE invites

Tenders for the Purchase of

the Whole or any part of 119,660 Shares of £5 each, fully paid, in SIEMENS BROTHERS & COMPANY, LIMITED, vested in him as Custodian by an Order made by the Board of Trade, in pursuance of Section 4 of the Trading with the Enemy Amendment Act, 1916, and dated 9th August, 1916.

The issued capital of the Company consists of 130,000 Shares of £5 each, fully paid.

The purchasers, who must be British-born subjects, will be required to make a sworn Declaration as to nationality and freedom from foreign control on a form to be obtained from the Offices of the Public Trustee.

The purchasers will also be required to satisfy the Public Trustee as to their financial and technical ability to carry on the business of the Company as efficiently as heretofore, or otherwise to the satisfaction of the Government.

A report upon the Company's operations and affairs has been prepared by the Company, in conjunction with the Company's Auditors (Messrs. PRICE, WATERHOUSE & Co.), and with Messrs. TURQUAND, YOUNGS & Co. Copies of this report can be obtained, subject as hereinafter mentioned, together with copies of Company's accounts up to the 31st December, 1915, on written application to the Public Trustee, Kingsway, W.C.

All applicants will be required to satisfy the Public Trustee as to any matter which he may think fit to investigate before copies of such Report or accounts will be supplied.

Intending Tenderers who desire to inspect the property of the Company, should apply to the Public Trustee for an authority to do so.

Tenders must be delivered, sealed, to the Public Trustee, Kingsway, W.C., on or before Thursday, the 14th June, 1917 (NOT APRIL) ED, AS PREVIOUSLY ADVERTISED), at Twelve o'clock Noon, and marked on the envelope, "Tender, Siemens Shares."

The Public Trustee does not bind himself to accept any Tender, and reserves to himself all rights in connection therewith.

Forms of Tender can be obtained from the PUBLIC TRUSTEE.

Dated this 9th day of February, 1917.

C. J. STEWART, Public Trustee,
Custodian for England and Wales.

APPOINTMENTS OPEN.

Works Superintendent or

ASSISTANT WORKS MANAGER REQUIRED by large well-known firm, Government controlled, making large and small engines, repetition and general work. Applications will only be considered from experienced engineers thoroughly conversant with latest manufacturing methods and who have made good in every way in similar position in large works. Permanent position to right man. State age, experience, and salary required. No one employed on Government work will be engaged.—Apply your nearest EMPLOYMENT EXCHANGE mentioning this Journal and A 2998. G 244

Wanted, Works Manager, for

Weldless Steel Tube Works; experienced in manufacture of all kinds tube for Admiralty, Engineering, Electrical, and Motor requirements. Knowledge of piercing, rolling, hot-drawing. Address, full particulars, in confidence, stating previous experience and salary required, G 404, Offices of ENGINEERING.

Marine Salvage Company in

the South of England has VACANCY for an experienced MANAGER who must hold or have held a similar position. Must be experienced in the raising of submerged vessels and conversant with latest appliances and methods for deep water work. Good business men with first-class experience and references only need apply. Successful applicant can have option of holding interest in the company should he desire. Age, salving experience, references, &c.—Address, G 440, Offices of ENGINEERING.

First-class Experienced

ESTIMATOR WANTED by Government controlled works making large and small engines, repetition and general work; man with thorough practical knowledge of machining and fitting, &c., who could control rate-fixing, progress, and demonstration. Only men thoroughly experienced need apply. Permanent position to suitable man. State age, experience, and salary required. No one employed on Government work will be engaged.—Apply your nearest EMPLOYMENT EXCHANGE mentioning this Journal and A 2997. G 245

Superintendent Rate Fixer, for

bench work in aeroplane factory N.W. London district. No one residing more than 10 miles away or already on Government work need apply.—Address, G 373, Offices of ENGINEERING.

LONDON COUNTY COUNCIL

Head Master Required for

the Bloomfield Road Central (B) School, Plumstead, Woolwich, S.E. Salary £300 a year, to £400, by yearly increments of £10.

The pupils enter the central school at the age of 11 and leave at the age of 15.

This school has an industrial bias and most of the pupils enter skilled industries, mainly of the engineering type. The head master should have qualifications and experience appropriate for the position.

Candidates must be ineligible for military service.

Application must be made on Form E 40 H/T (to be obtained on application to the Education Officer) accompanied by copies of recent testimonials, addressed to the Education Officer, E 19 London County Council, Education Offices, Victoria Embankment, W.C. 2, and must be received not later than Eleven a.m. on Monday, 16th April, 1917. Canvassing disqualifies.

JAMES BIRD, G 442
Clerk of the London County Council.

Electrical Engineer Required

to take full control of all electrical installations and upkeep in large Government controlled works (bulk of current from Corporation). Applications will only be considered from experienced men who have held similar positions with good records. State age, experience, and salary required. No one employed on Government work will be engaged.—Apply your nearest EMPLOYMENT EXCHANGE mentioning this Journal and A 2996. G 247

Wanted, an Experienced Con-

tractor's ENGINEER, accustomed to ferro concrete work. No one engaged on Government work nor resident more than 10 miles away need apply.—Apply, with copies of testimonials, to F. C., care BROWNS, 21, Tothill Street, Westminster, S.W.1. G 461

Large Engineering Firm,

Government controlled, REQUIRE the SERVICES of thoroughly experienced WORKS ENGINEER used to lay-out, erection, and complete equipment of up-to-date works; well versed in modern machining and manufacturing methods and the upkeep of plant for maximum output. Permanency to good man. State age, experience, and salary required. No one employed on Government work will be engaged.—Apply your nearest EMPLOYMENT EXCHANGE mentioning this Journal and A 2999. G 246

Assistant Chemist Required

for large Engineering Works on North-East Coast. One familiar with the analysis of Non-Ferrous Alloys preferred. No person already engaged on Government work will be considered.—Apply, stating qualifications, age, salary, and when at liberty, to your nearest EMPLOYMENT EXCHANGE, quoting No. A 3098. G 474

The National Boiler and

GENERAL INSURANCE CO., LTD., St. Mary's Parsonage, Manchester, REQUIRE ADDITIONAL INSPECTORS. Must be practical engineers or boilermakers of good experience with engines and boilers, should have theoretical knowledge, and be able to take dimensions and make neat sketches and mechanical drawings of boilers and engines. The duties include the examination of all parts of boilers, the indication and examination of engines. Commencing salary, £12 per calendar month or upwards, according to qualifications and experience. Applications from men eligible for military service are not invited.—Address, by letter only, marked "Inspector," giving age, outline of experience and studies, and copies of testimonials, EDWARD G. BILLER, Chief Engineer. G 459

Wanted, Assistant Engineer

for Munitions Works. Must have practical knowledge of all machinery, materials, &c. State age, experience and salary required.—Address, G 420, Offices of ENGINEERING.

Required, in Drawing Office

of a Government Department in London, a CIVIL ENGINEERING ASSISTANT; one experienced in structural steelwork and sewerage preferred. Must be a good draughtsman and ineligible for military service.—Apply by letter, stating age, experience and salary required, with copies of recent testimonials, to BOX No. 746, care of STREETS, 8, Serle Street, London, W.C. G 419

Foreman Moulder.—Wanted,

first-class man in controlled shop, Leicester. Apply, with full particulars, salary required, and when at liberty, to your nearest EMPLOYMENT EXCHANGE, mentioning this Journal and G 463.—No one already employed on Government work will be engaged.

Charge-Hand Grinder

WANTED, for the Tool and Cutter-Grinding Department of a large Company engaged on War Munitions. Must be thoroughly experienced in all branches of Grinding, and able to control men. No person already engaged on Government work will be engaged.—Apply your nearest EMPLOYMENT EXCHANGE, mentioning No. A 3097. G 467

Wanted, at Once, First-class

Jig and Tool DESIGNERS, also Plant and Machine Tool Lay-out DRAUGHTSMEN, by large engineering firm, Manchester district. Persons already on Government work need not apply.—Apply your nearest EMPLOYMENT EXCHANGE, mentioning No. A 3095. G 462

Wanted, Draughtsmen for

Jig, Tool, and General Design Work on Aeroplane Engines.—Men used to motor car or high-class small engineering work preferred. No person already on Government work will be engaged.—Apply, your nearest EMPLOYMENT EXCHANGE, mentioning No. A 3093. G 275

Wanted, First-class Jig and

Tool DRAUGHTSMEN, and MECHANICAL DRAUGHTSMEN for aviation work; high salary for first-class man. London, N.W. State age, experience, and salary expected. Persons engaged on Government work or beyond the 10 mile radius need not apply. — Address, G 440, Offices of ENGINEERING.

Draughtsman, Mechanical,

with knowledge of building construction, WANTED for factory in Silvertown district. No one engaged on Government work nor resident more than 10 miles away need apply.—Address, giving full particulars and wages required, G 460, Offices of ENGINEERING.

Draughtsman Wanted in

Westminster office for Government work of high importance. Accustomed to design of light accurate electrical and mechanical instruments. Some workshop experience essential. Permanent position with good remuneration for capable man. —State full particulars of age, training, experience and salary required to your nearest EMPLOYMENT EXCHANGE and quote No. A 3077. (Applications from men at present engaged on War work cannot be considered.) G 437

Wanted, at Once for Con-

trolled Establishment in South Wales, an EXPERIENCED DRAUGHTSMAN for general work. No person already on Government work will be engaged.—Applicants should state age, experience, and salary required to their nearest EMPLOYMENT EXCHANGE, quoting No. A 3064. G 389

Wanted, Mechanical

DRAUGHTSMAN for London. No one resident more than 10 miles away or already on Government work will be engaged.—Write, giving particulars of experience and salary required, to ELECTRO METALS, Ltd., 56, Kingsway, W.C. G 471

Wanted, Draughtsman for

the mechanical design of large electrical direct current machines. Nobody engaged on Government work will be accepted.—Write or apply to the nearest Board of Trade EMPLOYMENT EXCHANGE, mentioning this Journal and No. A 2631. G 457

Draughtsmen.—Wanted, in

Glasgow, several first class Draughtsmen experienced in the designing of Heavy Steel Works Plant, Rolling Mill Machinery and Hydraulic Machinery. No one already on Government Work need apply. Reply stating age, experience, when at liberty and salary required to your nearest EMPLOYMENT LABOUR EXCHANGE mentioning No. A 2795. G 360

Draughtsman Wanted, accus-

tomed to rolling mill work and general engineering. No person already on Government work will be engaged.—Apply your nearest EMPLOYMENT EXCHANGE, quoting No. A 3057. G 441

Assistant for Physical Test-

ing Laboratory; must thoroughly understand "Buckton" Tensile Machines and able to make own test reports.—State age, experience, and salary required to The TEST HOUSE SUPERINTENDENT, Queen's College, Birmingham. G 388

Required, by London Engi-

neering Works, JUNIOR DRAUGHTSMAN. One with three or four years' experience preferred. No applicants residing outside radius of ten miles or already employed on Government work can be engaged.—Please write stating age, experience and salary required, to G 451, Offices of ENGINEERING.

A Large Firm of Engineers,

in the Midlands, have an OPENING for a YOUTH of good education as premium pupil, the course to include both works and drawing office.—Address, 4259, Offices of ENGINEERING.

SITUATIONS WANTED.

Purchasing Manager, with

15 years' experience in obtaining supplies for largest manufacturing engineers, is DESIRING a POSITION. Has technical knowledge of materials, a very wide experience of the markets for raw materials, finished materials and machine tools; is considered a good organiser, and is accustomed to very extensive dealings.—Address, G 466, Offices of ENGINEERING.

Works Manager, 43, Practical

and Commercial, DESIRES POST; 25 years' experience in high-class steel foundries and steel works engaged on all classes of material.—Address, G 428, Offices of ENGINEERING.

Manager, Ammunition and

Engineering Works, OPEN for immediate RE-ENGAGEMENT. Qualified practical and commercial; wide experience. Age 43.—Address, G 433, Offices of ENGINEERING.

Structural and Architectural

Engineer (45); construction of works, industrial buildings, re-inforced concrete, steelwork, sewerage, roads, bridges; workshop experience, SEEKS POSITION in works or office.—Address, G 470, Offices of ENGINEERING.

Charge Engineer, Factory

Maintenance, machine tools, steam and electrical, printing machinery, constructional work, laying out of plant.—Address, G 452, Offices of ENGINEERING.

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B.C.T., ineligible, REQUIRES POSITION. 25 years' varied experience electrical, refrigeration, pumps, oil fuel. Highest testimonials.—Address, G 353, Offices of ENGINEERING.

A Thoroughly Qualified and

experienced Marine Engineer DESIRES POSITION, Superintendent or Assistant Superintendent Engineer, to large firm. Speciality: Oil tank steamers, burning oil. Expert marine draughtsman, experienced turbines, water-tube boilers and Admiralty work.—Address, G 424, Offices of ENGINEERING.

Experienced Architect and

Surveyor DESIRES POSITION for the duration of the war. Exceptional qualifications. Good knowledge constructional engineering.—Address, G 430, Offices of ENGINEERING.

Draughtsman (Invalided

Officer) OPEN for ENGAGEMENT; used to jigs, fixings and tools.—Address, G 454, Offices of ENGINEERING.

Foreman Blacksmith and

STAMPER DESIRES CHANGE. Under 35. Used to all classes of Munition work. Excellent references.—Address, G 405, Offices of ENGINEERING.

Tracer (Lady), 12 years' ex-

perience. Small fine work a speciality. Able to do detail drawing.—Address, G 464, Offices of ENGINEERING.

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First £100 Buys ¼ Share.

PAYN'S NAIL GUN.
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Floor-laying Extraordinary. Nails driven while standing erect. Operated by Hand, Electricity or Petrol.

Propositions relative to development invited.

Models can be tested and further particulars obtained from

THOS. PAYN, 134, Kennington Park Road,
London, S.E., England. G 449

Partnership Wanted by En-

gineer with general experience, where personal services and capital, about £2000, will secure satisfactory return.—Address, "660," WM. PORTEOUS & Co., Advt. Agents, Glasgow. G 456

FURTHER NOTES ON SCREW THREADS.

By W. C. UNWIN, LL.D., F.R.S.

Now that the whole question of the standardisation of screw threads is under reconsideration, it is desirable that data on which to form an opinion should be available. In a previous article (ENGINEERING, February 16 last, page 158) the advantage of clearance at the roots and crests of threads was examined and the effect of such a modification on the dimensions of the thread. Also an effort was made at a simplification of the mode of expressing the proportions of the thread in the Standards Committee Report. The aim was to alter as little as possible the existing standard and to maintain practically the same accuracy in tolerances. The examples dealt with were Whitworth threads, but Standard Fine Threads (B.S.F.) remain to be considered. Also, in view of the importance of internationalisation where it is possible, some account is given for comparison of the Standard Metric Thread (S.I.) which is now somewhat largely adopted in munition work in this country.

It is to be regretted in some respects that there are now two British systems of screw threads, B.S.W. and B.S.F., in general use. The time may come to consider whether the B.S.F., which is certainly best for some purposes, might not be used for all. That would be a simplification such as the Standards Committee has with great advantage effected in other cases. The Whitworth system has been in use since 1841, and has been of the utmost possible service to engineers. But if Sir J. Whitworth's original paper be consulted, it will be seen that it had no rational basis. The curious angle of 55 deg. was merely the average angle of a number of screws collected from different makers. Dr. Coleman Sellers adopted the angle of 60 deg., now largely used in the U.S.A. and on the Continent, on the ground that it could be more exactly reproduced than a less natural angle. It should not be overlooked that the stress on a bolt due to screwing up, which in many cases is considerable, especially in the smaller bolts, is larger in the case of the B.S.F. than in the case of the B.S.W. On the other hand the core diameter of the former is slightly greater than that of the latter.

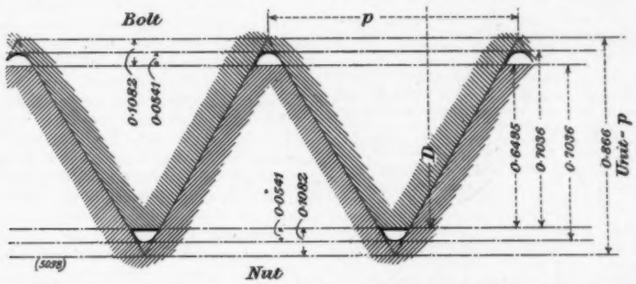


TABLE I.—*British Standard Fine Threads.*

Diameter D.	Pitch p.	Clearance on diameter 2 c.	Crest diameter.	Effective diameter.	Core diameter.
		Standard Bolt.			
0.5	0.0625	—	0.5	0.460	0.420
1.0	0.1000	—	1.0	0.936	0.872
2.0	0.1428	—	2.0	1.908	1.817
3.0	0.2000	—	3.0	2.872	2.744
		Modified Bolt with Clearance.			
0.5	0.0625	0.0063	0.5	0.466	0.426
1.0	0.1000	0.0100	1.0	0.946	0.882
2.0	0.1428	0.0143	2.0	1.923	1.831
3.0	0.2000	0.0200	3.0	2.092	2.764
		Standard Nut.			
0.5	0.0625	0.0007	0.503	0.461	0.421
1.0	0.1000	0.0010	1.001	0.937	0.873
2.0	0.1428	0.0014	2.001	1.910	1.818
3.0	0.2000	0.0017	3.002	2.874	2.746
		Modified Nut with Clearance.			
0.5	0.0625	0.0063	0.506	0.466	0.432
1.0	0.1000	0.0100	1.010	0.946	0.892
2.0	0.1428	0.0143	2.014	1.923	1.846
3.0	0.2000	0.0200	3.020	2.092	2.784

BRITISH STANDARD FINE THREAD.

The reasons for a clearance at crest and root apply in the case of the fine thread as well as in that of the Whitworth thread. Suppose it be taken provisionally equal to 0.05 *p*. The proportions of the thread are exactly the same as are given in Fig. 1 of the previous communication for the Whitworth thread. A chasing tool for a B.S.W. bolt can be used for a B.S.F. bolt if the number of threads per inch is the same.

By taking clearance out of the nut and slightly diminishing the height of thread, the core diameter of the bolt, on which strength depends, is not reduced. The height of triangular thread is 0.96 *p*; diameter to crest of bolt, D; diameter to root of bolt, D−1.18 *p*; diameter to crest of nut, D−1.08 *p*; diameter to root of nut, D+0.1 *p*; effective diameter, D−0.54 *p*. The annexed Table I gives some cases calculated for comparison with those in the Standards Committee Report.

Tolerances.—The following table gives a comparison of the tolerances for crest and root in the Committee's Report and tolerances taken at 0.03 *p*.

Diameter of bolt .. in.	0.5	1.0	2.0	3.0
Tolerance in report ,,	0.0018	0.0025	0.0035	0.0043
,, = 0.03 *p* ,,	0.0019	0.0030	0.0043	0.0060

In the B.S.F. the tolerances at root of bolt thread are a little greater, and the tolerances are minus for the bolt and plus for the nut. It is suggested that for a thread with clearance they may be plus or minus on both bolt and nut.

The following table gives a comparison of the pitch tolerance in the Committee's Report and a tolerance taken at 0.02 *p*, these being in a length equal to the bolt diameter.

Diameter .. .. in.	0.5	1.0	2.0	3.0
Tolerance in report ,,	0.0009	0.0015	0.0026	0.0033
,, = 0.02 *p* ± ,,	0.0013	0.0020	0.0029	0.0040

It will be conceded that the suggested rules for tolerance are much simpler than those in the Committee's Report.

With regard to the tolerance on effective diameter the Standards Committee appear to have calculated the effective diameters corresponding to the maximum and minimum pitches allowed by the tolerances in a length equal to the bolt diameter. The difference of these is taken as the effective diameter tolerance. It can be shown that with the tolerances suggested above this would make the effective diameter tolerances 0.0216 *p*.

But it is not clear that the method of the committee is rational, for there is nothing to secure that, dealing with work screws and not reference gauges, the tolerances on pitch and effective diameter in any given case match each other. Further, a table is given of allowances to compensate errors of pitch. To use this the pitch error must be known. Hence it would seem that a screw must be chased, its pitch error measured, and then the effective diameter corrected by the table. This does not seem practicable.

In the suggestions made the limits of tolerance in the Standards Committee Report have been closely followed. But the question of tolerances certainly requires reconsideration and experimental investigation.

As to the strength of bolts the very low working stress permitted in practice proves that their resistance to a statical load is relatively unimportant. No doubt shock and vibration play a large part in the conditions bolts must resist. It is very desirable that their resistance to repetition of straining action should be tested in a Wöhler machine. The more or less abrupt changes of section in a bolt are unfavourable to resistance to fatigue.

The International Metric Thread.—At the present time many engineers are working to French drawings and are using metric units. It does not appear that any difficulty arises in the workshop from the change from an inch to a millimetre unit.

The system of metric screw threads which has most authority in France, the *système international*, was settled at a conference in Zurich in 1898. The thread has an angle of 60 deg. (like the Sellers thread). The crests of the threads are flat-topped and there is a permissible clearance between crests and roots of 0.0541 *p*. It is not clear what advantage is gained by making the threads flat-topped, and there is this disadvantage: that it lessens the crest tolerance which the clearance would permit. Another point is that the clearance is taken equally from the core of nut and bolt. It would seem better to reduce slightly the height of thread, so as not to reduce the core diameter of bolt and lessen its strength. The height of the metric thread is greater than that of the Whitworth form thread of the same pitch, on account of the smaller rounding.

The annexed figure shows the International Metric Thread, with permitted clearance. The following are its proportions:—

Height of triangular thread	...	0.866 *p*
Diameter, crest of bolt...	...	D
,, root of bolt ...	...	D − 1.4072 *p*
,, crest of nut	...	D − 1.299 *p*
,, root of nut ...	...	D + 0.1082 *p*
Effective diameter ...	...	D − 0.6495 *p*
Clearance on diameter, 2 *c*	...	0.1082 *p*

Diameter D.	Pitch p.	Clearance on diameter 2 c.	Crest diameter.	Effective diameter.	Core diameter.
		International Metric. Bolt.			
mm.	mm.	mm.	mm.	mm.	mm.
0.5	0.13	0.014	0.5	0.416	0.317
1.0	0.24	0.026	1.0	0.844	0.662
2.0	0.39	0.042	2.0	1.746	1.451
5.0	0.90	0.097	5.0	4.415	3.733
20.0	2.50	0.270	20.0	18.375	16.480
60.0	5.50	0.594	60.0	56.425	52.257
		International Metric. Nut.			
0.5	0.13	0.014	0.331	0.416	0.514
1.0	0.24	0.026	0.688	0.844	1.026
2.0	0.39	0.042	1.493	1.746	2.042
5.0	0.90	0.097	3.830	4.415	5.097
20.0	2.50	0.270	16.75	18.375	20.27
60.0	5.50	0.594	52.85	56.425	60.59

Comparison of British and Metric Threads.

B.S.W.		B.S.F.		Metric.			
Diam.	Threads	Diam.	Threads	Diam.	Threads	Diam.	Threads
					per 100mm.		
in.	per in.	in.	per in.	mm.		in.	per in.
0.25	20.0	0.25	26	5	111	0.197	28.2
0.5	12.0	0.5	16	12	57	0.472	14.5
1.0	8.0	1.0	10	24	33	0.945	8.5
2.0	4.5	2.0	7	48	20	1.89	7.9
3.0	3.5	3.0	5	76	15	2.99	8.9

THE INSTITUTE OF METALS.

(*Continued from page* 279.)

THE meeting of the Institute of Metals was resumed on Thursday afternoon, March 22, being held, as on the previous day, in the Rooms of the Chemical Society. In opening the proceedings, the President, Sir G. T. Beilby, F.R.S., said the whole time of the meeting was to be devoted to the discussion of metal melting, with the object, as far as possible, of bringing out all that was best in present practice, and the Institute had, he might add, been very successful in getting papers likely to stimulate discussion. He took it that in melting metal the points of importance were rapidity of melting, the preservation of the purity of the molten metal, the control of its temperature, both in the melting process and in pouring, and, finally, economy of fuel, labour and repairs.

GAS FURNACES.

The president then announced that the four papers on metal melting by means of gas would be read in abstract by their authors and they would be discussed as a whole. The papers in question were as follow:—"Metal Melting as Practised at the Royal Mint," by Mr. W. J. Hocking; "Coal

Gas as a Fuel for the Melting of Non-ferrous Metals," by Mr. G. B. Brook; "High-pressure Gas Melting," by Mr. C. M. Walter, M.Sc.; "Contribution to Metal-Melting Discussion," by Mr. H. M. Thornton and Mr. H. Hartley, B.Sc.

Mr. Hocking's paper is reprinted on page 309 of the present issue. Mr. Brook read the following abstract of his paper.

Some years ago experiments were carried out in the University of Sheffield which went to show the material advantage possessed by gas over other fuels for the melting of non-ferrous alloys. These results are summarised in Table 1. They were sufficiently promising to prompt the author to carry out a severer test and one of longer duration. It was, therefore, decided that such tests should be carried out on material which demands probably the highest temperature of any industrial non-ferrous alloy, namely, cupro-nickel; that the test should extent over not less than 10 full days of 10 hours each, and commercial practice in the size of the ingot, &c., should be followed. It was the author's endeavour to provide melting data obtained from an experimental run on a sufficiently large scale to eliminate such misleading conclusions as are sometimes inseparable from the translation of laboratory experiments into works practice. A gas-fired pit furnace of a modern type was placed at the author's disposal, and it is the relative advantage of this fuel as compared with coke that forms the basis of the paper. The writer had hoped to embody data relative to an oil-fired pit furnace, but pressure of war work precluded this.

The following summary, in the form of question and answer, sets out the objects of the test and the deductions to be drawn therefrom:—

1. Would ordinary coal gas give a temperature that was sufficiently high for this alloy?

No difficulty at all was obtained in securing a temperature of 1,400 deg. C.

2. What was the relation between the coke-fired furnace and the gas-fired furnace from the following standpoints?

(a) The Relative Cost of Melting.

	Per ton alloy produced.
Average cost of melting with high-grade metallurgical coke	36*s.* 4*d.*
With gas at ordinary Sheffield rates	31*s.* 9*d.*
At the preferential rate allowed to users of gas for gas engines ...	24*s.* 2*d.*

(b) Relative Speed of Melting.

It was under this heading that the great advantage was shown by gas over coke.

The same weight of metal can be melted in the gas furnace in 52 minutes which required 82 minutes in the coke-fired furnace. When this advantage is translated into commercial practice the advantage is still more striking, for on two days during the test it was possible to obtain 12 heats in the 10-hour period, whereas the writer has only on very exceptional days been able to obtain seven heats from a coke-fired furnace per day.

(c and d) The Life of the Crucibles and the Wear and Tear of Lining and Burner.

The graphite crucibles of the same make have as long, if not a longer, life in properly controlled gas-fired furnaces as in coke. The lining of the furnace and the burner suffered no serious depreciation.

(e) Metal Losses.

Such loss was found to be below the average, and from the general stability ensured to the crucible mechanical loss ought to be far less than in the coke-fired type.

(f and g) Labour and Capital Charges.

The labour charges per ton of metal produced would be less in the gas-fired furnace, from the fact that a larger number of furnaces can be controlled by the same staff, and the output of such a team of men would be higher in the case of gas-fired furnaces.

Quality of Product.

The cupro-nickel was tested at every stage and was found to be satisfactory. The ultimate test, in the production of bullet sheaths, showed that the material was equal, if not superior in both quality and minimum failures, to any that had been produced in coke-fired furnaces.

The absence of ashes, the elimination of the wasteful process of "slagging," the economy of fuel, in ease of control, and the reduction of impurities introduced in the process of melting, are factors of considerable importance to the manufacturer, and confirm the writer's findings that the claims of coal gas as a fuel for the melting of non-ferrous alloys rest on a very sound economic basis.

We shall reprint Mr. Walter's paper on "Melting with High-pressure Gas" in a future issue. In it the author gave a detailed description of a furnace working with gas supplied at a pressure of 11 lb. to 12 lb. per square inch. The gas enters the furnace through an injector, thus drawing in with it the air required for its combustion.

With a battery of 12 of these furnaces installed in a foundry and employed in melting brass the consumption per lb. of metal melted averaged over the whole day was 7.6 cub. ft. of gas. In a larger furnace melting 72:28 cartridge metal the consumption was 6.2 cub. ft. of gas per lb. melted, whilst in melting cupro-nickel 9.4 cub. ft. of gas were required to melt 1 lb. of the alloy.

The following summary of the paper by Messrs. Thornton and Hartley has been prepared by the authors.

Thermal Efficiency—Fuel Consumption.

Coal gas is a more costly fuel in terms of British thermal units than furnace coke, and to attain success with gas-fired metal-melting furnaces an increased thermal efficiency is essential.

The thermal efficiency is dependent upon the pouring temperature of the metal, being lower the higher the temperature attained. The over-all efficiency calculated on the basis of the total consumption starting from cold is dependent upon the number of melts put through successively. The steady state efficiency, *i.e.*, the efficiency for individual melts after about the fourth melt, is about 30 per cent. for a pouring temperature of 1,000 deg. C. and 25 per cent. for 1,200 deg. C., the over-all efficiencies on the basis of six melts being respectively 21.6 per cent. and 17 per cent.

The requisite pouring temperature will depend upon the nature of the alloy and the size of the casting. In the experiments with brass quoted in this communication the pouring temperature has been 100 deg. C. above the liquidus for the particular alloy and probably represents the lower limit of the suitable pouring temperature range. To obtain a pouring temperature 100 deg. C. higher than this would involve approximately a 20 per cent. increase in gas consumption.

The presence of small amounts of metals foreign to true brass would not be expected to affect the specific heat of the alloy very much, although, of course, they may materially assist in the melting of brass by lowering the liquidus point to a marked extent. Thus in melting red brass it was poured at 1,090 deg. C., and about 20 per cent. more gas was employed than in melting a yellow brass which was poured at about 1,000 deg. C.

For a pouring temperature of 1,000 deg. C. yellow brass can be melted at an expenditure of 1,200 British thermal units per lb. of metal melted on the basis of six successive melts; with 12 successive melts this reduces to 1,030 British thermal units, and with 20 successive melts to 960 British thermal units.

Copper ingots have been melted at a consumption of 1,908 British thermal units per lb. on a basis of six successive melts, the over-all efficiency of the melting process being 17 per cent., the steady state efficiency being 25.5 per cent.

By comparing the efficiency result of the copper melt with that obtained during the brass melting, the efficiencies for intermediate pouring temperatures can be calculated, and from these the increase in gas consumption that would be required in order to obtain higher pouring temperatures for brass.

Metal Losses.

The vaporisation loss of zinc in the melting of brass has been investigated somewhat closely, and it has been found that with a low pouring temperature, *i.e.*, 1,000 deg. C., this need not exceed 1½ per cent. of the zinc originally present. With a red brass poured at 1,100 deg. C. the loss was somewhat higher, whilst when the temperature of the yellow brass was raised to 1,180 deg. C. the zinc loss rose to about 6 per cent.

The use of a flux does not appear to produce a smaller zinc loss than a charcoal covering, although it does lessen materially the amount of metal retained in a pasty condition in the skimmings. The best results appear to be obtained by the use of both charcoal and a little flux.

General Considerations.

The life of the pots obtainable in gas-fired furnaces would appear to be greater than in coke-fired furnaces, and the time required for the completion of the melt would appear to be less in the former case than is general in the solid fuel-furnaces.

Marked fuel savings result when the furnace is designed so that the metal is preheated before admission to the blast burner.

If both the metal and the air are preheated to the same temperature, then greater recuperation results from the brass than from the air. On the other hand, data obtained without preheating, and with only metal preheating, when compared with those obtained when there is preheating of both brass and air, would appear to indicate that some advantage results in preheating the air on account of its effect on the temperature attained in the combustion zone of the furnace as distinct from the advantage accruing from the mere transference of the thermal energy from the flue back to the melting chamber.

In moving a vote of thanks to the authors, Sir George Beilby paid a well-deserved tribute to the very clear and full abstracts which the authors had prepared. These, he said, put the meeting in possession of all the essential points of the papers.

The discussion was opened by Sir Thomas Rose, who said he had been much struck with the enormous advantages of using town gas in place of coke for metal melting, whether the process had to be carried out on a large scale as at the Mint or with small pots as elsewhere. He regretted that Mr. Walter had not made a direct comparison between the relative advantages of high-pressure and low-pressure gas. From the figures given for high-pressure gas, viz., 7.6 cub. ft. per lb. melted in the case of brass and 9.4 cub. ft. per lb. in the case of 80:20 cupro-nickel, it would appear that the gas consumption was substantially greater than with low-pressure working. It was certainly not necessary to use high-pressure gas for melting cupro-nickel, though possibly the plan might have advantages in the melting of pure nickel, for which an extremely high temperature was required. The speaker asked for further particulars of the flux referred to by Mr. Thornton as being added to protect the metal from contamination by the furnace gases, as his own experience had been that such fluxes were very liable to pass over into the mould on pouring, rendering the ingots unsound near the top.

Dr. R. S. Hutton, who spoke next, said that he was particularly grateful for Mr. Hocking's record of several years of continuous work with gas furnaces at the Mint, where the operation had been throughout under such careful control as would hardly be found elsewhere. Until he read the paper he had rather looked on gas melting as a process still in the experimental stage. Many, no doubt, were trying it, but it was, he fancied, hardly being exploited on a commercial scale as a continuous process. The melting of 12,000 tons at the Mint showed, however, that gas melting was not so much of an experiment as had been thought. If, however, the process was to stay and expand the gas undertakers must pay more attention to commercial requirements and afford a much better supply than any of their customers were at present receiving. Some of their failings were no doubt due to the war, but he did feel resentment at the way the opportunity had been taken to legalise a very low calorific standard. Both the regularity of the pressure and the calorific value were far below what was wanted. He had been much impressed with the way gas was wasted in furnace work. Well-designed furnaces were installed, but were handed over to workmen with but the crudest ideas as to what was occurring inside the furnace. They learnt accordingly to control the operation by indirect means; by the noise, or by the character of some flame emerging from the furnace. It was necessary, the speaker said, in all gas-furnace work to provide some simple device for control and adjustment which should be fit for use by untrained men. He had seen such an appliance (based on the Pitot tube) which gave a continuous record of the gas and air supplied. He could confirm Mr. Thornton's experiences with the preheating of gas. It was, in fact, more important to preheat the gas than the air. He had also been struck with the record figures in gas consumption given by Mr. Thornton. These were, no doubt, explained in part by the preheating, but complete data as to the furnace used would be of much interest.

Mr. H. James Yates said he had been much struck with the data as to gas consumption with high-pressure supplies as given in Mr. Walter's paper. These he could confirm from his own experience, extending over two years. The author gave a consumption of 9.4 cub. ft. of "high-pressure" gas per lb. of cupro-nickel melted. With town gas at its normal pressure and an air supply at 3 lb. per square inch, 1 lb. of the cupro-nickel alloy could be melted with from 5.8 cub. ft. to 6.7 cub. ft. of gas. For common brass, 72:28, Mr. Walter's figure was 6.2 cub. ft. per lb., whilst with gas at the town pressure and the air supply at 3 lb. pressure but 2.9 cub. ft. were required. Indeed, he knew of a case in which this alloy was melted day in and day out with a gas consumption which averaged only 2.5 cub. ft. per lb. Moreover the life of the pots ran from 80 to 100 melts or more, it being a bad pot which would not be good for 80 melts. Messrs. Thornton and Hartley had stated that in melting brass the consumption per lb. melted was 4.93 cub. ft. in the first heat and 1.4 cub. ft. in the last. The speaker knew of a case in commercial practice where the average over the whole day was 1.49 cub. ft. of gas per lb. melted. The conditions were, however, exceptional, with men working on the premium bonus system. He knew moreover, of cases in which cupro-nickel was being melted with an expenditure of from 5.8 cub. ft. to

8.5 cub. ft. per lb., copper with 4.8 cub. ft. per lb., and 70 : 30 or 72 : 28 brass with from 2.9 cub. ft. to 3.5 cub. ft. per lb.

Mr. R. C. Harvey said that Dr. Hutton had criticised the plan of controlling the working of a gas furnace by the appearance of the flame produced. The method was, however, about the most practical that it was possible to have. Mr. Walter, in his paper, had pointed out the necessity of dampers in the flues. If these were omitted, and the gases passed along to a large chimney giving a heavy draught, the furnace was actually "exhausted" and more gas run through it than there was actual need of. With a damper in the flue and a small hole in the cover of the furnace allowing a flame to pass, this flame showed at once whether it was of a reducing or oxidising character. With respect to the paper by Mr. Brook, the melting of a 30-lb. charge of yellow brass in the furnaces described was hardly commercial practice. Not one of the three furnaces using respectively coke, oil and gas was being worked at its proper capacity. The proper charge for the coke and gas furnaces was 90 lb., and for the oil furnace 120 lb. The consumptions recorded were therefore misleading. In the experiments on brass described by Messrs. Thornton and Hartley he observed that the metal was poured, quenched, and remelted 24 times in succession. Its composition would not, he thought, be the same on the last as at the first melt.

Dr. W. Rosenhain, F.R.S., said that the high claims made for the efficiency of gas-firing were surprising in view of the cost of producing the gas and of the large volume of heated gases which went up the chimney. Possibly the favourable showing of gas lay in the excellence of the gas furnace itself, and that the coke furnace was really a very bad one. He asked if it were not possible to improve the coke furnace. He could not help thinking that its low thermal efficiency was due to avoidable losses of heat. Where regeneration was used, as in steel-making, of course gas heating was the best of all. It was, however, useless to jacket the furnace and pass the gas or air through the jacket, as the preheating thus effected was at the expense of the furnace. For efficiency the preheating must be done with waste heat. There was no difficulty in applying a regenerator to coal gas, and for high-temperature furnaces the plan was a very practical one. It was thus possible, with a supply of coal gas and air under pressure, to maintain a furnace temperature of 1,650 deg. C. The air was supplied at 80 lb. to 100 lb. per square inch, and drew in more air by an injector action. In this way an intense flame was obtained, large amounts of gas being consumed in a small space, thus producing high temperatures. Such a system might be necessary in melting the chromium-nickel alloys, which required temperatures of more than 1,450 deg. C. In ordinary furnaces there was a large loss of heat by conduction through the walls. This could be lessened by suitable design and the use of proper materials. Zirconia, for example, was a refractory of low conductivity. By preventing these conduction losses the temperature of the interior walls of the furnace would be raised, and they might run in consequence. Ordinary refractories only stood because they were really air-cooled by the conduction through the walls. The wash of carborundum mentioned by Mr. Hocking was a great protector, preventing the erosion of furnace linings even if of somewhat inferior quality. It was relatively cheap and easily applied.

Mr. H. L. Reason said that the question of high-pressure gas-firing *versus* coke should be approached with an open mind. The cleanliness and general tidiness pertaining to the gaseous fuel were undoubted advantages, but the noise was a drawback. Again, whilst admittedly good results could be obtained by experts, they had in practice to operate their foundries with ordinary workmen. The latter, in the case of coke-firing, did not care to use more fuel than necessary, as they had to handle every pound put into the furnace. Gas, however, could be turned on without trouble. The air-blast system was that which appealed most to the speaker, and he believed it would be found suitable for all cases. He thought that Mr. Brook's estimates of cost were not above criticism. With gas at 10*d.* per 1,000 cub. ft., coke would cost 16*s.* per ton rather than 24*s.* The tests made would, he thought, have been more reliable if the pots had held 100 lb. to 200 lb. of metal instead of 30 lb. The results with cupro-nickel were very bad for coke, and he thought that a better result would have been secured by using forced blast. He noted that the initial cost for coke and gas furnaces was estimated at much the same, but a stack had not been included for the gas. This was, however, he understood, as necessary with high-pressure gas as when coke was used as the fuel.

Mr. A. J. Smart said that variation in the gas pressure was one of the troubles met with in using town gas. He noted that whilst in one part of his paper Mr. Hocking referred to the gas pressure as constant, in another he mentioned certain regulating taps which were used to correct for pressure changes. He asked whether any form of gas-governor was installed at the Mint. Apparently, from the paper, nothing was done till the gas pressure dropped, but as this would convert the flame from a reducing to an oxidising one, much damage might occur in the flaking of the crucibles before the adjustment was effected. He would also be glad to know how the special crucibles used differed from those made for coke-fired furnaces. He would also ask why the author recommended that in shutting-down the gas supply should be cut off before the air. If the air entered the hot furnace after the gas was cut off there would, he thought, be the liability of oxidising and flaking the crucibles. Why could not both be shut off simultaneously? He noted that the very low consumption of some 2 cub. ft. of gas per lb. of brass melted, which was recorded by Messrs. Thornton and Hartley, was obtained with a 70-lb. furnace. The brass roller used a furnace of 150 lb. to 200 lb. capacity, and the speaker's experience was that the larger the furnace the greater the consumption; the figures might therefore prove misleading. The same remark applied to the life of the pots, which varied with the size. As for the 45 to 50 melts obtained with a 70-lb. pot, he would like to know whether this was a commercial figure or an experimental result possible only with very careful manipulation. It would also be well to add whether sand or chill moulds were used, as in sand-casting a pot would run to 5 or 6 more heats than in chill-casting. Returning to the matter of gas consumption, he thought the 4 cub. ft. to 4½ cub. ft. of gas per lb. melted recorded by Mr. Walter was more in accord with actual practice.

Mr. H. Hartley, as a maker of gas furnaces, expressed his surprise that Mr. Hocking had got the results recorded. Had he preheated his gas, the speaker would have expected a fuel saving of 33 per cent., equivalent to some 2,000*l.* to 3,000*l.* for the five years covered by the record. He noted, moreover, that the gas consumption in practice was nearly 70 per cent. higher than in special tests, and he thought this pointed to a waste of gas somewhere. Mr. Walter's figures, again, were higher than the speaker would expect, even in the absence of preheating. The two papers emphasised the necessity of expert control of the plant if the best results were to be obtained. The wastage might, he considered, be taken as the difference between average running figures and those obtained in special tests. If too much gas were passed into the furnace, not only was there a higher flue loss, but the temperature in the combustion zone was lowered.

Mr. Spiers observed that the economical use of crucibles was just as important as economy of gas. Moreover, as one of the ingredients had to be imported, the difficulty of getting supplies was the same as in the case of food. It was therefore most essential to economise. It was wonderful how the life of the crucibles increased when the bonus system was introduced. Speaking generally, he did not consider that any one fuel was better than its competitors, gas, oil and coke had each its good points. Much depended on the intelligence of the men. If on "pouring" the gas were turned off slightly the life of a crucible was increased enormously. The crucibles supplied to Mr. Hocking were "specials," but their extra-long life was largely due to the way they were looked after.

Mr. J. Dewrance said that the advantages of gas were so great that it would be universally adopted were it not for some accompanying drawbacks. The metal losses were less than with coke, and double the output was obtained for the space occupied. His experience (with 100-lb. to 400-lb. pots) was that so long as the furnaces were new the advantages of gas were enormous, but the furnaces would not last. This was not because the men were stupid, but from the conditions of the case. With coke-firing there was a fairly uniform heat all the way up the furnace, but with gas there was a concentration of heat in one spot, and to get the necessary average temperature the maximum had to be very high. His firm were studying the question of obtaining better refractories, but until this was done he did not consider that gas-firing was a practical proposition. Moreover, with gas-firing the failures with 400-lb. pots were serious, so he did not think that the plan could yet appeal to the practical founder.

Mr. Brayshaw said that in one works cupro-nickel was being melted on a large scale with a consumption averaging 6 cub. ft. to 7 cub. ft. of gas per lb. In another large works where pure nickel was melted the relative fuel cost taken over a period of 18 months amounted to 4*s.* 2*d.* per unit with coke and 1*s.* 9*d.* with gas. The life of the pots averaged 80 melts, and specific instances of 120 melts had been recorded in commercial practice. One large firm, he might add, was now consuming 500,000 cub. ft. of water-gas per hour, almost all in metal melting. A gas furnace was supplied by the speaker's firm to Messrs. Johnson and Matthey for heating up spongy platinum to a welding temperature. The furnace had a capacity of 1,000 oz., but in place of raising the metal to a welding heat only, it actually fused it. He had himself measured a temperature of 1,800 deg. C. in a furnace operated with gas from the town mains and an air supply at 2 lb. per square inch. The pyrometer used was supplied by the Cambridge Scientific Instrument Company, and was verified by the makers after the test. For his own part he believed that there was no future for high-pressure gas-firing, or even for gas with air at 2 lb. or 3 lb. pressure, since cupro-nickel could be run with gas and air supplied at a 12-in. water-gauge only. A low-pressure plant of this kind was enormously cheaper to instal and operate, and would, he felt sure, have great developments in the future.

Sir George Beilby, in bringing the discussion to a close, said that he had had some experience with gas-fired furnaces, and fully concurred with Mr. Brayshaw in his objections to the high-pressure system. We could, he said, get all we wanted with low pressures, both of gas and air. Some twenty years ago he had adopted water-gas with a calorific value of 350 British thermal units per lb. for furnace firing. The furnace was not fitted with any form of blowpipe, but both gas and air were merely led in under a low pressure, provision being made for keeping the mixture adjusted to the right proportions. The results were eminently satisfactory. The working temperature required, it was true, was only 1,100 deg. C., but they could easily have gone some hundreds of degrees higher, having no difficulty in running down the furnace lining. Room must be provided for the combustion of the gas. He noted that none of the authors gave analyses of the flue gases, but he thought that when 6 cub. ft. or 7 cub. ft. of gas were taken to melt 1 lb. of metal, a good deal of combustible must be passing into the flues. With both gas and air supplied under positive pressure no tall chimney was required, Such a chimney gave a pull on the furnace which varied with wind and weather. In the plant already referred to the regenerator consisted of steel tubes, so arranged that no cutting flame could get at them, and they proved most satisfactory. He was anxious to put his experience at the service of any member. As they knew, the Government had appointed a committee to promote fuel economy, and the speaker was a director of this. He had taken up the work from patriotic reasons, and he wished, both personally and through the committee's experts, to give every assistance in carrying out the objects in view. He would ask in this the co-operation of the members of the Institute. The idea that high pressures were necessary in using gas for metal melting was a bogy, since the low-pressure system was effective and could be installed quite cheaply.

A few minutes being still left before the close

of the afternoon meeting, Mr. J. W. Hocking replied to part of the discussion on his paper, reserving further observations for contribution to the Journal of the Institute. He said that the crucibles used by him were a special mixture of which the makers alone had the secret. The pressure of the gas supplied to the Mint was fairly regular, though it might be improved. The quadrant taps he mentioned in his paper were not used on account of fluctuations in the supply pressure, but because as the furnace heated up the back pressure in it increased, and regulation was required accordingly. With coke-firing the crucibles served for 12 heats and with gas for 18, these being average everyday figures. In pouring, the crucible was away from the furnace for about 8 minutes, and its life was lessened accordingly. Objection had been taken to the practice of turning off the gas before the air. Actually the two were turned off almost simultaneously, but such difference as existed was in favour of the gas. The idea of the regulation was to avoid the possibility of an explosive mixture on opening the furnace. The long continuous run recorded in the paper was made not with a view to establishing record figures, but to make certain that the burners would stand up to heavy continuous work, and this they proved capable of doing, the whole battery of furnaces being ready for use the day following the run. One speaker had said that with gas there was a liability to intense local heating, endangering both furnace and crucible. In the furnaces at the Mint the inlet was to one side of the axis of the pot, and the flame travelled spirally round both crucible and wall. There was no local concentration of heat, and both wall and crucible were preserved. It should be noted that for success the wall must be kept smooth. If allowed to get rough it quickly deteriorated. At the start of every day's work the wall was examined and patched if necessary.

(To be continued.)

13-IN. CENTRE SHELL-BORING LATHE.

WE illustrate on this page a shell-boring lathe constructed by Messrs. John Robson (Shipley), Limited, of Shipley, Yorkshire, who have paid special attention to the design of heavy tools suitable for operation by the unskilled labour with which our munition factories are, to so large an extent, manned.

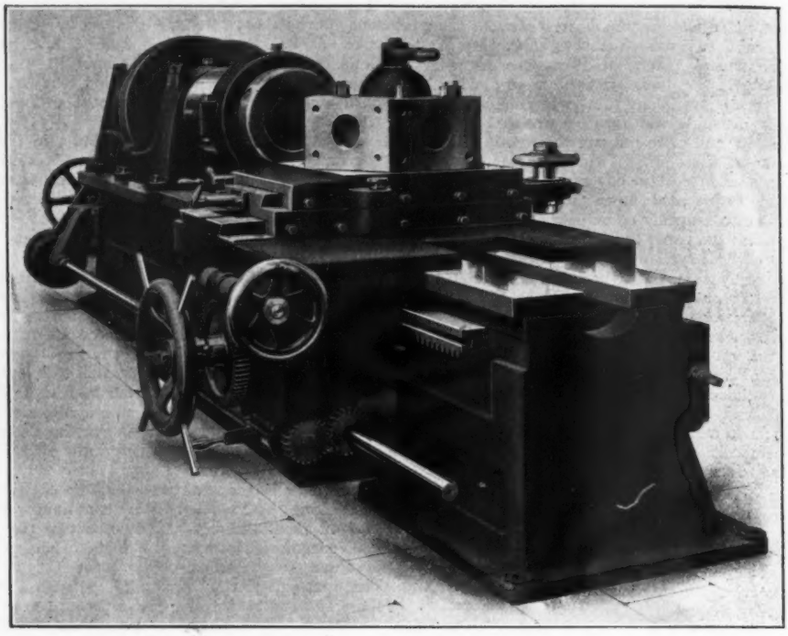
The tool shown has been specially designed for boring shells from 8 in. to 12 in. diameter. A rigid straight bed is used, carried by a cabinet standard at each end. The guiding surfaces are square-edged, and a tank on runners is provided to facilitate the removal of chips. The fast headstock is fitted with a solid spindle 6 in. in diameter in the front neck. This runs in adjustable parallel bearings of gun-metal. A three-step cone for a 5½-in. belt is provided, and as the machine is intended for use mainly with the back gears in, a gear reduction of 13 : 1 is given, thus securing a high belt speed. End-thrust is taken by a ball collar at the front bearing, The shell is carried in a special form of bell-chuck, the front end of which is supported by a lubricated stay.

The saddle has a long bearing upon the bed, and an adjustable slip is provided for taking up wear. Power sliding feed is provided, engagement being obtained by a drop worm. Disengagement may be either by hand or by means of an adjustable stop carried on the bed. The apron is double-walled, and all the power feed gears are supported by two bearings. A slow hand feed for bottoming is obtained by means of a second worm and wheel controlled by the hand-wheel at the right hand side of the saddle, and a safety device prevents the simultaneous engagement of the two feeding motions. Two cross-slides are provided, and these may be made to work either independently or in unison as follows :—(*a*) *For Parallel Boring with Spade Cutter.*—A parallel push pin passes through lugs on the cross-slides into a hole in the saddle, thus anchoring the turret exactly central with the fast head spindle. (*b*) *For Form Boring.*—The centralising pin is removed and a runner mounted at the back end of the bottom slide is screwed down until its periphery is in contact with a former plate having the desired contour. The former plate is mounted on a bracket bolted to the back of the bed, but a screw is provided to give endwise adjustment in order to obtain the correct relative positions between the bore and outside of the shell. The thrust of the cut is taken by three springs under the bottom slide, so that any excessive irregularity will push the runner clear of the former plate, thus avoiding damage. The top slide is controlled by a screw carried in the bottom slide, and by this means the cut is "put on."

A hexagon turret 20 in. across the flats is provided, located in its six positions by a spring plunger (withdrawn by a lever at the front of the cross-slide), and locked by a lever on the top. The holes for the boring bars are 4 in. diameter, and each bar may be fixed by a clamp bolt and bush. In addition there are four tapped holes in each face, so that brackets may be attached if desired. As this machine is intended for shell boring only, one rate of feed is provided, but this is obtained by change gearing, so that the best rate of feed may be secured.

13-IN. CENTRE SHELL-BORING LATHE.

CONSTRUCTED BY MESSRS. JOHN ROBSON (SHIPLEY), LIMITED, SHIPLEY.



STAMPER'S LOADING TRUCK.

ON the opposite page we illustrate an appliance patented by Mr. C. W. Stamper, of Dover Yard, Berkeley-street, W. 1, facilitating the loading of motor lorries. It will be seen from Figs. 2 to 4 that the chassis of the lorry is fitted with rollers and a winch, and that over these rollers a platform or body can be drawn into position and automatically locked there. Any form of body can be adapted for this purpose, being fitted with angle irons (Fig. 4) to act as guides while it is being drawn up, and to hold it secure against sideways motion during transport. The purpose of the arrangement is to permit of a loaded body being rapidly put in place, so that the lorry is not subject to waiting while the body is being filled. It can come into a warehouse, discharge its loaded body, take up another which is waiting, and start off on a fresh journey with the minimum of delay. The object is that an expensive motor may be kept constantly at work and deal with the maximum number of ton-miles in a day.

The illustrations show a very simple form of body mounted on a loading truck (Fig. 1), by which it can be horse-drawn about a works to pick up its load before being backed on to the lorry. The loading truck has no springs, and therefore keeps at a constant height. Its rear end (Fig. 3) has side guides to enable it to be backed centrally on to the trolley, so that the angle irons on the body stand fair with the rollers. The wheels have also a certain amount of play on the axle arms to facilitate centring. Upon the loading truck is a body or skeleton frame capable of carrying a 3-ton load, and this can be drawn from the loading truck on to the lorry by a wire rope and a winch, transferring the load in a short time from the one vehicle to the other. To keep the wire rope taut a compensating device is introduced into it (Fig. 5) to take up the slack.

When the body is being drawn up into position it is automatically locked to prevent it being displaced by the act of starting, or when the lorry is ascending an incline. The lock is shown in Fig. 3. When the detachable body is drawn on to the lorry it passes over the lock lever, depressing it. The lever then drops into the vertical position, engaging with the lock-plate under the body; and it is then hitched on to the spring, which holds it at an angle of about 30 deg. with the vertical and in firm engagement with the lock-plate. When the detachable body is to be removed the lever is temporarily held in a horizontal position, so that it clears the plate and allows the body to be removed.

Several descriptions of bodies, suitable for different kinds of traffic, can be used with one chassis with facility.

EXORBITANT METAL PRICES IN SWEDEN.—Owing to the scarcity of certain indispensable metals and the manner in which unscrupulous speculators have succeeded in securing what limited stocks there are in the country, some prices have risen to exorbitant levels. Tin now costs 23 to 24 kronor per kilogramme (about 14*s.* per lb.), a rise of about 800 per cent. Antimony is held at 20 kronor per kilogramme (about 11*s.* per lb.), a rise of 2,000 per cent.; lead costs 2 kronor (about 1*s.* 2*d.* per lb.), a rise of 600 per cent.; and copper, which before the war cost 1 krona 75 öre per kilogramme (about 11*d.* per lb.), now costs 6 kronor (about 3*s.* 6*d.* per lb.).

ROYAL INSTITUTION.—The following are the lecture arrangements at the Royal Institution after Easter :—Professor C. R. Beazley, two lectures : Russian Development : (1) The Old Free Russia ; (2) The Rise of Moscow. Professor Charles S. Sherrington, two lectures : (1) Tetanus : Its Prevention, Symptoms and Treatment ; (2) Rhythmic Action in Muscle and in Nerve. Professor D'Arcy W. Thompson, two lectures : Architectural Design in Organisms—The Laws of Growth and Form. Professor W. W. Watts, two lectures : The Flow of Ice and of Rock : (1) The Movement of Glaciers ; (2) The Flow of Rock. Professor H. S. Foxwell, two lectures : Industrial Finance after the War : (1) The Character of the Industrial Struggle of To-day ; (2) Its Financial Needs : How they can best be met. Professor Gilbert Murray, two lectures : Pagan Religion at the Time of the Coming of Christianity : (1) Misleading Preconceptions (Dogma, Mythology, Statues), The Raw Material—Dea Roma ; (2) Dea Roma, The Mystery Religions, Philosophy, Conclusion. Professor William Bateson, two lectures : The Chromosome Theory of Heredity and the Alternatives. Alfred Noyes, two lectures : Modern English Poetry. Professor G. H. Bryan, two lectures : Principles of Aerial Navigation. Professor Sir J. J. Thomson, six lectures : The Electrical Properties of Gases. The Friday evening discourses will begin on April 20. Professor R. H. Biffen : The Future of Wheat-Growing in England ; J. Dundas Grant : The Organs of Hearing in Relation to War ; H. Wickham Steed : Some Guarantees of Liberty ; Professor John Joly, Radioactive Haloes ; Professor Frederick Soddy, The Complexity of the Chemical Elements ; J. Barcroft, Breathlessness ; J. H. Balfour Browne, The Brontes : A Hundred Years After ; Professor Sir J. J. Thomson, Industrial Applications of Electrons.

STAMPER'S LOADING TRUCK FOR MOTOR LORRIES.

(For Description, see opposite Page.)

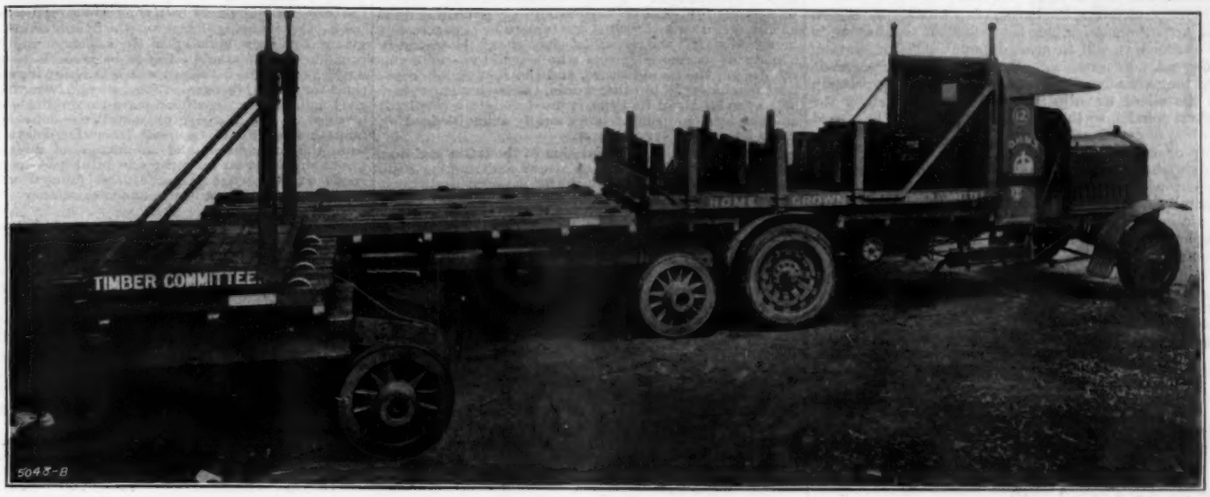
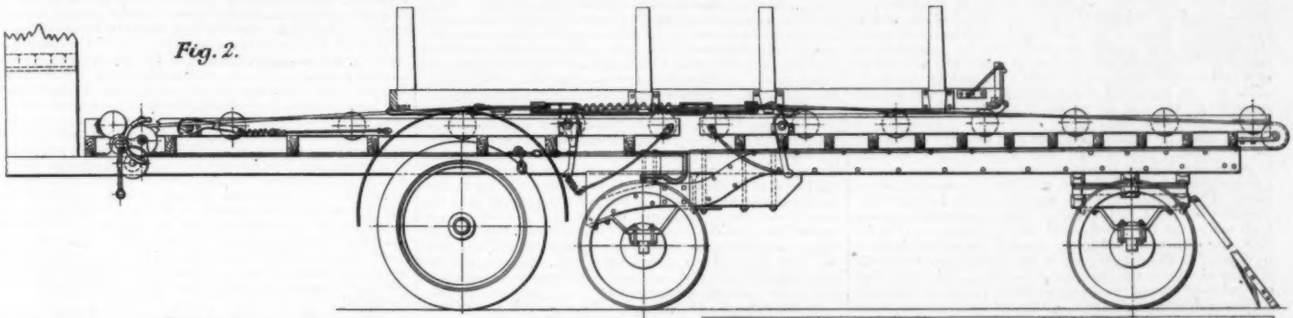
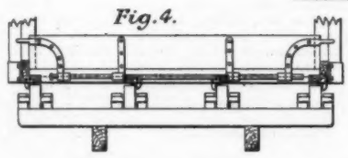
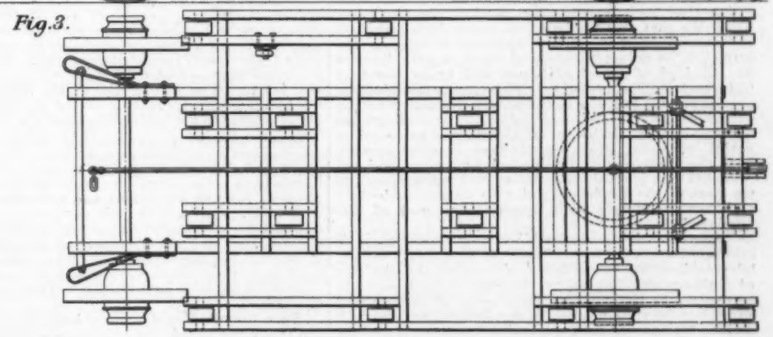
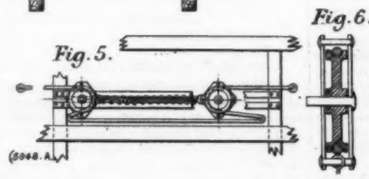


FIG. 1.









OIL-FIRED NAVAL BOILER.

WE illustrate this week on Plates XXV and XXVI a marine water-tube boiler fitted by Kermode's Limited, of Liverpool, with Mr. J. J. Kermode's pressure-jet system for burning oil fuel, this boiler being one constructed for the Norwegian Government, and having some special features of interest. The general design of the boiler is shown clearly by Figs. 1 and 2, while the remaining views, Figs. 3 to 14, give details of the oil-burning equipment. The boiler, which has 5,080 sq. ft. of heating surface, is constructed for a working pressure of 260 lb. per sq. in., and is to give an evaporation of 67,300 lb. of water per hour from and at 212 deg. F. It will be seen that the boiler is arranged for firing from both ends, a plan which saves weight and space, and which, when the boiler is extremely long, aids in attaining an even distribution of flame in the combustion chamber. As will be seen from Figs. 1 and 2, provision is made for baffling the escaping gases, with a view to ensuring that the volume of flame is as uniform as possible throughout the whole capacity of the furnace.

At each end the boiler is fitted with four Kermode's pressure jets, with the corresponding air-cones and automatic louvres, the general arrangement being shown by Figs. 3, 4 and 5, and larger-scale views of one of the jets, with its accompanying air-controlling arrangements, being given in Figs. 8, 9 and 10. As will be seen, each jet is mounted on the front plate of a rectangular chamber projecting 11½ in. beyond the end-plates of the boiler casing, this chamber being also fitted above and below the jet with the automatic louvres for the admission of air which form one of the features of the Kermode system. As shown in Fig. 8, each louvre is mounted on axes which are placed out of the centre of the width of the louvre, so that the latter is opened by the pressure of the air acting, under the influence of the draught, on the larger area on one side or the other of the line of axes. The extent to which the louvres can open is controlled by the adjusting screws shown in Fig. 8, while the louvres are at all times free to close, and thus provide a safeguard against back-firing.

Referring again to Fig. 8, it will be seen that the spray from the pressure jet is discharged into an air-cone which forms another feature of the Kermode system. This air-cone consists of two tubes, one cylindrical and fixed to the wall of the boiler casing, and the other coned, as shown, and sliding within the tube first named. Both tubes have openings for the admission of air formed in them, and the inner tube can, by means of the screw shown in Fig. 8, be adjusted so as to regulate the effective area of the air inlet openings or ports. As will be seen from the sections of the inner and outer bodies of the air-cone, the ports pass obliquely through the tubes so as to give to the entering air a whirling motion. It should be noted that the air-cones can, if required, be be renewed while the boiler is in full commission.

The construction of the Kermode pressure jet is shown by Figs. 11 to 14. The oil fuel, supplied under pressure, enters the burner at the side and passes along the annular space between the outer wall and the inner cylinder E. This cylinder is screwed into the shell of the burner and abuts at its front end against the cap-nut A. Grooves are formed in the end of the cylinder E, as shown in the separate view, Fig. 15, and through these grooves the oil obtains access to

the discharge opening, which is controlled by the conical end of the spindle C, the position of which is adjusted by a hand wheel fitted with an adjustable pointer and fixed index pointer. In the latest types the Kermode pressure-jet burners are fitted with a cartridge and disc at B, so that renewals can be effected without condemning the burners as a whole. Moreover, this arrangement enables the power of the burner to be changed at will to meet different rates of burning if desired. Nevertheless, all the burners are so made that they are controllable either by varying the pressure on the oil or by adjusting the valve formed by the central spindle, so that the oil discharge can be varied from a few gallons per hour up to 100 gallons per hour or even more.

As we have already stated, the oil is on the Kermode pressure system supplied to the burners under pressure—generally not less than 150 lb. per sq. in.—no steam or air being used to effect its pulverisation. The oil supplied is carefully filtered and is heated so as to have a temperature of 180 d g. at the burner. The system is now in extensive use, it having been fitted to a number of vessels, amongst them to the Swedish battleship *Sveriege*, which is provided with arrangements for auxiliary firing (oil and coal), and to the London Fire Brigade float *Beta*.

STANDARDISATION OF CARGO SHIP MACHINERY.

*Standardisation as Applied to the Machinery for Cargo Boats.**

By MR. D. B. MORISON.

ALTHOUGH it is imperative that maximum effort, individual and collective, should be concentrated on winning the war, it will be well if our energies can be so directed that, without in any way prejudicing the main issue, they may be helpful towards a solution of the stupendous industrial problems ahead of us, and in avoiding the dangers of "too late." In engineering and shipbuilding the period of grace will be extended by reason of the general shortage of tonnage, but the deluge of world competition will be with us ultimately as sure as night follows day, and our success or failure will depend entirely on the use we make of time and opportunity between now and then.

It is futile for capital to expect that labour will consent to any great reduction in wages. It will be equally hopeless for labour to expect the maintenance of the present high rate of wages without concession on its part. Therefore let both capital and labour seek whether by joint endeavour it will be possible to pay high wages in the future and yet maintain our trade. The requisites are first a candid acknowledgment by labour of the economic law that good general trade is dependent on maximum production, and, secondly, capital must recognise that maximum production entails correspondingly high pay. Capital and labour must realise that their interests are parallel, not divergent. Assuming that this fundamental principle is accepted, then the onus of organised preparation falls on the employer, as unless unrestricted effort is well directed its standard of useful efficiency will be so low that ultimate failure is inevitable. There can be no industrial success in this country of the degree demanded by the obligations of our national indebtedness without the full employment of labour at the highest standard of useful efficiency. Such a standard is only possible with the most perfect mechanical equipment and the most efficient general organisation and management on the part of the employer, and with unrestricted effort and correspondingly high wages on the part of the employed.

"Forewarned is forearmed" is only true if there is intelligent appreciation and immediate action. On the labour side we have abundant evidence that the Minister of Labour and his more progressive associates do appreciate to the full the importance of unrestricted effort, but the vital question is, can they convert the rank and file? That the danger is real and pressing is obvious from the fact that even in the stress of this terrible war an increase in wages is only too often accompanied by a decrease in hours worked.

On the employers' side it has been popularly advanced that salvation is to be found by standardisation. The manufacture in multiple of an arbitrary design is not standardisation, it is merely repetition with the object of obtaining greater output. To standardise is: accurately to determine the best—progressively to maintain the best—and to produce of that best the greatest quantity by means of organised specialisation in labour, in methods and in machinery. Progressiveness in standardisation with regard to design depends on how nearly reasonable finality has been reached. In the case of a pin or a pen, for example, improvement in design is barely possible. In a machine comprising an aggregation of parts, such as a self-binding reaper, the desired effect having been obtained, progress can only be associated with means for reducing cost of manufacture or increasing the rate of work.

The economic effect of obtaining the greatest possible power from steam by means of an engine is of such vast importance that the determining of the best, and the progressive maintenance of the best, are factors which also determine whether any given type shall continue to exist. Consequently the initiation of a standardised marine engine requires extraordinary care and ability in order that the standard shall be unsurpassable in efficiency both thermally and mechanically. A single mistake in determining the best in a standard engine prejudices for its entire life the commercial value of the ship that it drives, whether the effect of that mistake be reflected in steam inefficiency or mechanical inefficiency. It would seem, therefore, to be of paramount importance that the initial decisions should be vested in a body of marine engineers who are life specialists in the design, the manufacture, and the running of cargo-boat machinery. In other words, the engine must start off as the leader of its type, it must maintain this lead, and the leadership must be generally acknowledged by cargo-boat machinery experts.

The incorporation in one design of the latest and best practice as affecting steam efficiency and running costs would provide a measure, but the measure itself must be tested and adjusted by continuous research, both technical and practical, on organised lines, so that it is always "The Standard." Failing a Government engineering bureau for the whole country the engineering institutions would appear to be the best means to the desired end.

An experiment in this direction has recently been made by the North-East Coast Institution of Engineers and Shipbuilders. The members and council have commenced on very conservative lines by preparing a guidance specification for triple-expansion engines for cargo boats, based on the best practice of the various specialised builders on the coast. It is proposed to begin on simple lines for this year, but an annual revision will be made in order that the specification may be gradually extended and kept thoroughly up to date with a view to securing the maximum rate of progress in technical advance and commanding the confidence and promoting the ultimate interests of all concerned, viz., of the engine-builder, the shipbuilder and the shipowner. Other specifications on similar lines are to be prepared for quadruple engines, geared turbines, and internal combustion engines.

Assuming that in the general problem of standardisation this guidance specification of the North-East Coast Institution represents the best now obtainable, the next step is to provide means whereby there shall be progressive improvement by continuous investigation and research, supported by organised and collective practical experience. With regard to the latter it is not sufficient that the engine-builder gets rid of his goods on the day of the trial trip. There should be some system of co-operation between the engine-builder and shipowner whereby the general results in coal economy and costs for repairs over a prolonged period, certainly beyond the usual six months' guarantee, are recorded and rendered available. In order to secure the funds for carrying out this scheme, it has been suggested that the cargo-boat engine-builders of the North-East Coast should be invited to adopt the specifications at a small fee per horse-power. As the money so collected would be entirely devoted to promoting the progress of the associated industry, it is hoped and expected that there will be an enthusiastic response.

In the matter of auxiliaries the research committee appointed by the Council of the North-East Coast Institution will exhaustively test approved apparatus connected with a marine installation and publish in their Transactions the results obtained. This will secure a reliable means of ascertaining the true performance of any apparatus so tested, and as the results will carry the hall-mark of the Institution for accuracy, the value of the scheme to the industry generally is obvious.

In the matter of boilers and shafting, complete standardisation of marine machinery is blocked because the Board of Trade, Lloyd's Registry, and the British Corporation issue independent rules which are based on physical facts as a constant and individual opinion as a variable. Just a very little co-operation and mutual sympathy would enable all the existing differences to be adjusted, to the great advantage of the many industries involved. Manufacturers generally anticipate with confidence that these authorities will do their part in promoting national progress by working together with this object.

When Lloyd's Registry revised their rules some years ago they requested the assistance of a committee of experts selected by the leading marine engineering institutions. This committee has been very successful, as the various members, all of whom occupy leading positions in the several shipyards and engine works, are in such direct touch with practice that their experience establishes mutual confidence, to the great benefit of all concerned.

A similar committee of experts was appointed by these institutions about the same time, with the object of providing a means whereby the many irritating disputes and misunderstandings which so frequently arose some years ago between the Board of Trade and the manufacturers could be overcome, the collective technical experience of the members being available in the event of new rules being issued or old rules revised. Each member of the committee was prominently associated with a shipbuilding yard or a marine engineering works, and all gave their services with enthusiasm, although often at great personal inconvenience. In any progressive country on the face of this earth except our own such a committee would have been welcomed, and its expert capacity officially recognised and utilised to the fullest extent for the common good; but the traditional antagonism to innovation, no matter how desirable, has prevailed. For twenty years this committee has given of its best to the cause of progress. It has never received adequate recognition or encouragement from the Department of State it was appointed to assist. It is gratifying to record, however, that a serious attempt is now being made to devise some mode of procedure for making full use of the existence of this committee in the national interests.

Assuming the various surveys decide to harmonise their rules so that standard design, scantlings, and physical properties of material may prevail throughout the range of cylindrical boilers as now supplied to cargo boats, the economic effect on the manufacture of the material and the building of the boilers would be very pronounced. It would at once be possible to prepare a series of standard designs, with accompanying specifications for plates, furnaces, tubes, stays, rivets, &c. The steel manufacturer could estimate the probable demand produce in bulk, and give immediate delivery. The boiler-builder would be freed from the delays arising from the preparation and submission of designs, and would simply order from the scheduled list—receive the goods exactly when required, and proceed with the manufacture with an economic continuity hitherto impossible.

The following are examples of divergence between the surveys:—

1. For a single-ended boiler 15 ft. 6 in. in mean diameter, 11 ft. 6 in. long, 180 lb. working pressure, thickness of shell $1\frac{13}{32}$, tensile $28\frac{1}{2}$ tons to $32\frac{1}{2}$ tons per square inch, diameter of rivets $1\frac{7}{32}$, pitch of rivets $9\frac{1}{2}$.

Working Pressure of Shell.

	lb.
Board of Trade	= 183
Lloyd's Registry	= $210\frac{1}{2}$
British Corporation	= $204\frac{1}{2}$

2. For the working pressure for a suspension furnace 3 ft. 10 in. inside diameter, $\frac{7}{16}$ in. thick:—

	lb.
Board of Trade	= 185.3
Lloyd's Registry	= 200.5
British Corporation	= 196.5

An examination of the tables of pressure for these furnaces reveals to the curious that for thicknesses below $\frac{9}{16}$ in. the Board of Trade allows a greater working pressure, the thinner the furnace, than Lloyd's, and for furnaces over $\frac{9}{16}$ in. thick Lloyd's allow a greater working pressure, the thicker the furnace, than the Board of Trade. Arbitrary requirements also often involve unnecessary cost, as, for example, limitation by the Board of Trade of rivet pitch to $10\frac{1}{2}$ in., with a tensile of rivets of from 27 tons to 32 tons, necessitates an increase in shell tensile for large boilers, for which abnormal extras have to be paid to the steel-makers. A brilliant example of what can be achieved by well-directed collective effort is the standardising of stationary boilers in the United States of America by a committee of experts appointed by the American Institution of Mechanical Engineers. In this connection the following extract from a speech by the late President of the Board of Trade would seem to be appropriate: "It will, in fact, be apparent to all close observers that a country which fails to regulate and foster its industries in the national interest cannot in the nature of things long survive the rivalry of another country where the industries are so regulated and fostered."

The only detail of the engines proper affected by the surveys is the shafting, and the following is an analysis for a set of triple-expansion engines with cylinders 25 in., 41 in., 68 in., by 48-in. stroke and 180-lb. boiler pressure.

Diameter of Crank and Thrust Shafts.

Board of Trade	= 12.76
Lloyd's	= 13.32
British Corporation	= 13.08

Diameter of Tunnel Shaft.

Board of Trade	= 12.12
Lloyd's	= 12.69
British Corporation	= 12.42

In determining the diameter of propeller shafts, each of the three surveys adopts a different basis. Lloyd's and the British Corporation consider the diameter of the propeller—the British Corporation the block coefficient of displacement of the vessel, whilst the Board of Trade consider neither. Assuming a propeller diameter of 17 ft. 6 in., and a block coefficient of displacement of 0.78, at four-fifths moulded depth, diameter of propeller shaft:—

Board of Trade	= 13.47
Lloyd's	= 14.29
British Corporation	= 14.67

That is to say, a shaft to the Board of Trade requirements would be deemed 22 per cent. too weak by the British Corporation and 16 per cent. too weak by Lloyd's. In practice the shafting of a cargo boat is practically never made to the rules of the Board of Trade, as when the machinery is built to the Board of Trade survey it is invariably associated with either Lloyd's or the British Corporation. If, therefore, these two surveys could see eye to eye and bring their shafting rules into line, a great advance would be made towards completely standardising the reciprocating engines of a cargo boat.

With the advent of the geared turbine and its probable extended use in the near future, it might reasonably have been expected that the various surveys would at least have formulated rules on a common basis. Such, unfortunately, is not the case. Lloyd's and the British Corporation adopt shaft horse-power, the Board of Trade indicated horse-power, Lloyd's rule giving the larger shaft. This state of affairs is perhaps not surprising in view of the fact that aloofness has hitherto been a national characteristic. Force of circumstances will compel us to modify this attitude, and to recognise that friendly co-operation will be the factor which will

* Paper read at the Institution of Naval Architects, March 28, 1917.

determine whether we sink or swim in the coming great race for industrial supremacy.

Broadly speaking, industrial methods in this country have been completely revolutionised since the war began, because we have been driven to recognise the dominating influence of intelligently directed energy as a factor in the economics of production, and it is unquestionable that the magnificent response to the national demand for colossal quantities of war material resulted from the cultivation of intelligent effort and concentration of organised method. The actual ascertainment of what is possible has been accompanied by an industrial awakening after a dangerously prolonged sleep, and as a fortunate consequence we shall be immeasurably better able to face possibly perilous competition than ever before, provided we sustain our efforts and profit by our experience. Intelligent direction increases the useful efficiency of labour enormously, so that by concentrating on method, employing the most suitable equipment obtainable, and organising physical effort, such a high rate of production can be obtained as to demonstrate without a shadow of doubt the certainty of an employer being able to pay high wages, but labour must respond with unrestricted production and enthusiastic co-operation. This does not mean great physical effort by labour, but reasonable and continuous effort during a full working day. In this connection the war has revealed the high standard of useful efficiency attained by women, especially as workers of machine tools, and to their lasting credit be it said that the steadily progressive production in many munition factories is due entirely to the unceasing desire on the part of the women always to do their best.

To obtain all that is commercially possible from standardised production it is necessary to manufacture continuously a given article in the best way by the best means at the best speed, whereby the efficiency of each factor is unity. The greater the number manufactured, the less becomes the percentage of attendant expenses. Therefore in cases where the value of the article is considerable and the demand great, the commercial success attainable may be phenomenal. Quantity is a controlling factor in all cases, so that maximum success in the standardisation of marine engines can only be obtained by the co-operation of the greatest number of builders.

Merely as an illustrative example let us consider the position on the North-East Coast. The various engineers who specialise in cargo-boat machinery produce collectively, say, 200 sets of reciprocating engines per annum. The following is a rough classification of the parts of the main engines only :—

Main Divisions of Engines.

I. Cylinders.	
Cylinders	600
Covers	600
Liners	200
Pistons	600
Valves	600
II. Columns.	
Columns	1,200
Guide plates	600
Guide bars	1,200
III. Bedplate.	
Bedplate	200
Bearings and keeps	1,200
M.B. bolts	2,400
M.B. nuts	4,800
IV. Main forgings.	
Piston rods	600
Connecting rods	600
Main bolts	1,200
Cranks	600
V. Valve Gear.	
Eccentrics	1,200
Eccentric straps and rods	1,200
Radius links	600
Drag links	1,200
Reversing shaft	200
VI. Condenser.	
Body	200
Doors	400
Water head	200
Tube plates	400
Tubes	250,000
Ferrules	500,000
VII. Pumps.	
Air pump	200
Circulating pump	200
Feed pump	400
Bilge pump	400
Sanitary pump	200
Levers, &c.	400
Drag links	800

Taking the steel forgings, and adding the thrust, tunnel and propeller shafts, the approximate total weight would be about 14,000 tons. If this amount were concentrated at a convenient centre, the steel cast, the ingots forged, and the forgings rough-turned, and if the works were of such size that this demand was only a portion of its output, then the cost of production would be so low as to enable the engine-builders to buy cheaper and to sell cheaper. The destination of these forgings for machining would depend on available facilities and transport, the object being a continuity of operation under the most favourable conditions possible. Th heavy castings would be produced from standard patterns, all prepared in consultation with the iron-foundry management, and the design being standard, the foundry management could with confidence provide the best labour-saving tackle. When delivered to the engine works the castings would be dimensioned by means of standard apparatus and machined from continuous supply. The tens of thousands of engine valves, fittings and other details would be classified and manufactured in bulk in specially equipped departments in the best ways, by the best means and at a cost quite unapproachable by present methods.

In cases where an aggregation of parts is not sufficient to secure the benefits of production in bulk those parts should be purchased from manufacturers whose business it is to produce such parts. For example, take condenser ferrules. A condenser ferrule machine can produce 400 per hour. Even if the yearly demand were half a million the machine would produce them in about 1,200 hours, or, say, 24 working weeks, thereby being operated at half its capacity. Complete standardised production of ferrules and similar details would involve the use of the greatest number of automatic machines that could be supervised by one skilled operator and one or more unskilled assistants. One skilled machine setter and three unskilled assistants could probably manage up to 20 automatics. Therefore the difference between one machine working half its time with one operator and 20 machines working continuously with four operators is an indication of the possible savings by organised manufacture in bulk.

Take as another example the large bolts such as are required for main bearings, piston rods and connecting rods, and which would aggregate about 10,000 per annum. So great a number of practically similar articles would admit of the purchase of special turret lathes capable of finishing bolts up to 5 in. diameter, with provision for completing all operations from the first rough cut to the final screw cutting and finishing, and if the number of machines were adjusted to maintain their full working capacity the cost of production would again be very favourable.

These few examples indicate the possibilities of standardised manufacture as applied to cargo-boat engines. The system is co-operative and is the direct antithesis in its inception and in its results to the destructive competition which has been so rampant and ruinous in past years. In manufacture the day of conservative and scattered individual effort is over—it leads to certain ruin. Success lies only in concentration by collective effort and the pooling of individual interests for the common good. The industrial problems of the future must be faced, and faced quickly—moreover, they must be solved, and solved quickly. The onus of responsibility falls primarily on capital, in the provision of standardised organisation, direction and equipment whereby the best is accurately determined and the best is progressively maintained; thereafter capital and labour must co-operate in standardising rapid production, so that good general trade may be promoted by steady employment at high wages, to the lasting benefit of the industries concerned and the general welfare of the entire community.

THE INSTITUTION OF ELECTRICAL ENGINEERS: WIRING RULES.—In view of the great demand by the Government for small stranded wires, the council have decided to permit for the period of the war the use of single-strand conductors up to No. 14 S.W.G. (see Rule 42).

ECONOMY IN THE USE OF RAILWAY WAGONS.—In view of the extreme importance of securing that the utmost possible use shall be made of the available supply of railway wagons, the Board of Trade have now issued orders, which come into force in Great Britain at the beginning of April, fixing the times beyond which the retention of a railway wagon by a trader will be an offence under the Defence of the Realm Regulations. The times allowed are, in general, one complete day for loading and two for unloading. Three days (four in Scotland) are allowed for unloading shipment traffic at ports, and two days are allowed in Scotland for loading wagons with coal for shipment. The Orders do not apply to coal traffic in England and Wales. Further Orders give power to railway companies themselves to unload wagons which are not unloaded by the trader within the prescribed times, and to make use of private owners' wagons on the return journey, so that the unnecessary haulage of empty wagons may be avoided. These Orders are being printed as Statutory Rules. Where necessary the periods at present allowed before demurrage charges accrue will be amended so as to accord with the periods fixed by these Orders.

EXPORTS TO SOUTH AFRICA: NEW REGULATIONS.—The High Commissioner for the Union of South Africa has been advised by his Government that a local committee has been constituted in South Africa for the purpose of dealing with all orders for the Union of South Africa placed in the United Kingdom for materials in respect of which there is a restriction of manufacture or export. The committee will be constituted on April 2 next, from which date no orders placed in South Africa for execution in the United Kingdom will receive consideration by the Priority Department of the Ministry of Munitions unless such orders are accompanied by the recommendation of the local committee. The procedure laid down by the Ministry of Munitions in regard to classification certificates is as follows :—All demands on the United Kingdom, properly formulated, shall be submitted to the local authority, who will sort, classify and make recommendations. They shall issue certificates to applicants direct, who will send them to their manufacturers in the United Kingdom, who, in turn, will submit them to the Priority Department of the Ministry of Munitions for final priority classification. It will thus be seen that there will in future be no necessity to obtain the support of the High Commissioner in regard to any such orders.

THE LATE MR. ROBERT GORDON SHARP.

THE city of Leeds, and the engineering industries within it, have suffered a serious loss in the death of Mr. Robert Gordon Sharp, which occurred on the 21st inst., at his residence, West Hill House, Chapel Allerton, Leeds. Mr. Sharp was not only an engineer, but also a man of business who held broad views on the relations of capital and labour. He sympathised with the aims of labour, and was the friend and wellwisher of the men, both those employed by his firm, the Leeds Forge Company, Ltd., and the many thousands who contributed to the prosperity of the town and district. We can ill spare men of that class at a time when new conditions are being created, and when a fresh system has to be formed in the early future. They possess the confidence of both parties, and if the old state of suspicion is to give place to more cordial relations we must employ as intermediaries those who have earned the esteem of the working classes in pre-war times. This is not to be done by professions and flattering speeches, but is the outcome of rectitude of conduct and a warm sympathy with those who follow the humbler paths of life.

Mr. Sharp had served the Leeds Forge Company first as works manager and later as general manager. Up till the day of his death he continued to promote the prosperity of the company, which owed much to his skill and energy. He served his apprenticeship in the locomotive works of the Great North of Scotland Railway at Aberdeen, and later was employed in the drawing office at Messrs. Kitson and Co.'s Airedale Foundry. Subsequently he held appointments in the locomotive departments of the Great North of Scotland Railway at Aberdeen, and of the Midland Railway at Derby.

Mr. Sharp was born at Keith, N.B., on March 10, 1864, and leaves a widow and a son, the latter being an officer in the West Yorkshire Regiment now serving in France.

SPITZBERGEN COAL.—Sweden is about to follow Norway's example and start rational coal mining on a large scale at Spitzbergen. A substantial company has been formed, rich coalfields have been secured, and this summer a small Swedish town will be built, on a height close to Van Meyen Bay, near to the sea, where the conditions are all that can be desired for shipping. A power station will be built, whence power will be transmitted to the coal mines. There will also be a wireless station, which will co-operate with the wireless station at Green Harbour; this, in its turn, is in touch with Norway. An expedition, comprising engineers and some 120 men, intends to start from Tromsö in the beginning of June, and the Swedish company intends to keep up the working throughout the year.

EXTENSION AND COMBINES OF SWEDISH INDUSTRIES.—The Separator Company, Stockholm, has during the last financial year earned net profits amounting to 10,770,306 kronor. It is proposed to declare a dividend of 16 per cent. and to increase the capital from 28,000,000 kronor to 42,000,000 kronor. by issuing 70,000 free shares and 70,000 new shares at a price of 150 kronor, their nominal value being 100 kronor. The two important engineering companies, the Atlas Company and the Diesel Motorer Company, have been combined in one concern with a share capital of 20,000,000 kronor, for which capital the shares of the two companies and their affiliated undertakings have been secured, also a portion of the shares in the American MacIntosh and Seymour Corporation. A board comprising several distinguished men in finance and industry is at the head of the new concern. (1 krona equals 1*s.* 1½*d.*)

ELECTRIC POWER SUPPLY IN THE UNITED KINGDOM.—The President of the Board of Trade has appointed a committee to consider and report what steps should be taken, whether by legislation or otherwise, to ensure that there shall be an adequate and economical supply of electric power for all classes of consumers in the United Kingdom, particularly industries which depend upon a cheap supply of power for their development. The committee is constituted as follows :—The Right Hon. F. Huth-Jackson, chairman; Mr. H. Booth, Mr. James Devonshire, Mr. G. H. Hume, Mr. John Kemp, Mr. H. H. Law, M.Inst.C.E., Mr. C. H. Merz, Sir Charles Parsons, K.C.B., Sir John Snell, M.Inst.C.E., Alderman C. F. Spencer, Mr. James Falconer, M.P., and Mr. A. J. Walter, K.C. The secretary of the committee is Mr. M. J. Collins, to whom all communications on the work of the committee should be addressed at the Board of Trade, 7, Whitehall-gardens, London, S.W. 1.

MANCHESTER ASSOCIATION OF ENGINEERS.—The annual meeting of the above Association was held on Saturday last, the 24th inst., the chair being taken by Mr. F. W. Reed, President of the Association. The secretary, Mr. Frank Hazelton, submitted the annual report of council, from which it appeared that there were 648 members on the membership roll, and that the balance standing to the credit of the Association amounted to £6,692. Mr. Joseph Phillips Bedson, of Messrs. Richard Johnson and Nephew, Bradford Ironworks, Manchester, was elected president for the ensuing year. Messrs. H. H. Asbridge, S. Boswell, R. Onions, J. H. Widdowson and F. Walthew were elected to the council. A cordial vote of thanks was passed to the retiring president, Mr. F. W. Reed, for the very able services he had rendered to the Association during his year of office. Subsequently an interesting paper was submitted on "The Testing of Steel," by Mr. Harry Brearley, of Sheffield.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scotch Steel Trade.—While the conditions which mark the steel industry in the West of Scotland continue to run on most satisfactory lines, so far as general activity is concerned, even the phenomenal output is insufficient to meet the demands made by Government, either directly or indirectly, for every class of steel required for purposes of the war. To all other consumers steel is practically unobtainable, except with a high priority certificate, and unless in the case of some small shipments to the French and Italian Governments, export, meantime, is entirely a thing of the past. Everything points to a continuance of these conditions for some considerable time to come, as events both in the Eastern and the Western theatres of war will put a very heavy strain on producers of steel material. The pressure from the shipyards is also very great, ship plates, boiler plates and sections being in such constant and ever-increasing demand that the strain of keeping pace with this is distinctly felt. Steel for shell bars is as much in request as ever. Prices are nominal and much on the level of last week's quotations.

Malleable Iron Trade.—There is no cessation of business in the malleable iron trade, makers finding it necessary to strain every nerve in order to meet the requirements of their customers, of whom, of course, our own and certain of the Allied Governments have first claim. While Government control does not exist to any appreciable extent, it is extremely difficult to maintain the output at the desired level, although even the present output is far in excess of anything ever attempted before. The production both of steel and iron is most extensive. "Crown" bars continue to be quoted at about 15*l.* per ton.

Scotch Pig-Iron Trade.—The stringent regulations governing the disposal of pig-iron are assisting very materially in the matter of something like an equal distribution according to the several necessities of the consumers, for the demand, far from diminishing, is steadily on the increase—especially for hematite. Little foundry iron is available for other than Government purposes at the present, but large quantities of forge quality are going direct to the iron works, and, of course, every possible ton of hematite is being rapidly consumed at the steel works employed on Government contracts. Under existing conditions shipments abroad are steadily dwindling down to a very low ebb.

To Increase the Output of Merchant Ships.—The appointment, by the First Lord of the Admiralty, of local committees in the different shipbuilding areas to carry out the Admiralty scheme for expediting and increasing the output of naval and mercantile shipbuilding has been received with much satisfaction and keen interest on the Clyde. The chairman of the Clyde and Scotland (East Coast) Committee is Sir Thomas Munro, who, as clerk to the Lanark County Council, has come much into prominence with various schemes of national importance, particularly during the past two and a half years. Associated with him are Mr. J. B. Hamilton—at one time traffic superintendent of Glasgow tramways, and now Assistant Director of Shipyard Labour, and commercial manager for the city of Leeds; and Mr. J. R. Bond, director of the technical section of the Shipyard Labour Department, and formerly general manager of the London and Glasgow Shipbuilding Yard, Govan. Under the tactful and discriminating guidance of these gentlemen, who have already got to work, there is every prospect of the best possible results being obtained from the Clyde yards.

Steelworkers' Advance of Wages.—Considerable satisfaction is being expressed in the West of Scotland in connection with the advance of wages which comes into operation next week, or at least with the first full pay in April. This advance of 5*s.* per week will affect the men in quite a number of the unions, as well as the boys and youths also employed in iron and steel works, who are to receive an advance of 2*s.* 6*d.* weekly.

Engineering Apprentices.—As iron and steel manufacturers are experiencing much difficulty at the present time in obtaining the services of likely lads as apprentices, a conference was held a few days ago between representatives of Clyde engineering employers and the School Board of Renfrew, when a display of work carried out by the pupils of the evening continuation classes was on view. The high standard of the work, particularly that of the shipbuilders' class, was much admired, and several of the employers spoke to the different points of view now to be considered in relation to the wage-earning capacity of apprentices. Present-day economic conditions seemed to demand that as soon as a boy was able to work it was incumbent upon him to take up even unskilled labour, so long as he received the highest possible rate of remuneration. It was suggested by one speaker that Government might take the matter in hand, so that some arrangement of compensation might be ensured to apprentices receiving the usual low rate of pay.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

South Yorkshire Coal Trade.—There are no new developments to record, as the "controlling" of the mines has affected the position to such an extent that there can be very few departures from what is now established war custom. The changed order, however, does not bring about the much-to-be-desired alteration in deliveries from the pits, and there is still a great amount of delay, which has a serious effect at the works and depots. The house coal section is the worst sufferer in this respect, for this class of coal has to be diverted from its ordinary channels to make up any shortage in the manufacturing section, which, of course, is to-day of paramount importance. Works are not faring so badly, and are getting ample supplies for daily running, though they cannot build up surpluses. Gas companies continue to receive a fairly large amount on account of contracts, but do not find the collieries disposed to look with a favourable eye at the invitations to renew these contracts. Slacks are tight, and seem to be growing scarce. Cokes are being used upon an enormous scale for steel-making purposes, and this keeps values at a high level. The export position is full of difficulties, which render trade with neutrals a matter of almost superhuman effort. Quotations:—Best branch handpicked, 20*s.* 6*d.* to 21*s.* 6*d.*; Barnsley best Silkstone, 18*s.* 6*d.* to 19*s.* 6*d.*; Derbyshire best brights, 18*s* 6*d.* to 19*s.* 6*d.*; Derbyshire house coal, 17*s.* to 18*s.*; best large nuts, 16*s.* 6*d.* to 17*s.* 6*d.*; small nuts, 15*s.* 6*d.* to 16*s.* 6*d.*; Yorkshire hards, 16*s.* 6*d.* to 17*s.* 6*d.*; Derbyshire hards, 16*s.* to 17*s.*; best slacks 12*s.* to 13*s.*; seconds, 10*s.* 6*d.* to 11*s.* 6*d.*; and smalls 7*s.* 6*d.* to 8*s.* 6*d.* per ton at the pit.

Iron and Steel.—The demand for all grades and classes of steel still remains very active, but with the elastic expansion of production there is a satisfactory output. The reopening of the Renishaw Ironworks could not come more opportunely. File makers do not report the receipt of such large orders as was their wont during the latter part of last year, but they still have a good deal of work on hand, especially for the British war departments. The busy state of the agricultural engineering works grows rather than diminishes. Largely through the initiative of Mr. Henry Brearley, the Firth-Brearley Stainless Steel Syndicate, Limited, has been formed to control and work the patent rights which have been granted Mr. Brearley, the inventor of stainless steel, in several countries, including Canada and the United States. Messrs. Brown, Bayleys, as well as Messrs. Thomas Firth and Sons, are interested in the new company. The project is expected to have a big influence upon the Sheffield cutlery trade as a whole.

Sheffield Trade Matters.—The annual meeting of Messrs. William Jessop and Sons, which was held in Sheffield on the 23rd inst., was noteworthy for two important anhouncements by the chairman, Alderman Hobson, one of the city's foremost business men, and a gentleman who has earned a reputation as an authority upon whom the Government rely for Sheffield trade matters. Mr. Hobson stated that the after-war trade development of the Sheffield trades was being impaired by the action of the authorities in regard to profits. He was of the opinion that as capital could only be spent now at an inflated price, firms who embarked upon after-war preparations should be allowed to write-off the inflation out of the profits obtained at the time of the inflation. Alderman Hobson also informed the meeting that the firm, long cut-off from its American customers in the matter of high-speed steel, was now in danger of being unable to send them carbon steel. This interruption of business was a grave matter, but he relied on the high quality of their products attracting their customers again when they were free to deal with them once more.

Messrs. Hadfield's Meeting.—Presiding at the meeting of Messrs. Hadfield's, Limited, at Sheffield, on Monday, Sir Robert Hadfield, the chairman, stated that those who criticised their dividend because it was 30 per cent. were evidently forgetful of the fact that the company had made special efforts to expand its output on behalf of the country, and had taken advantage of special facilities which lay to its hand. In one of their special lines of work they were giving the Admiralty almost two large-calibre shells at the price paid for one in other countries. In one item alone their improvements and information were now saving the Government a sum of not far short of six figures per annum. One example of the growth of output was shown that in a large-calibre shell they were now turning out as much as 35,000 to 40,000 more than before the war. This had been the result of much planning and organisation. In another large shell they were turning them out at the rate of one per minute—that was, ready to receive the high explosive charge—so that a week's work, stretched out on end, would result in shells of this size extending five miles.

NOTES FROM THE SOUTH-WEST.

Cardiff.—There has been discussion concerning the suggested application of Newcastle licences for the shipment of South Wales coal or for the fixing of neutrals, but as yet nothing has been accomplished to relieve the harassing difficulties of exporters, and second Admiralties are quoted at 24*s.* to 25*s.*, and best drys at 23*s.* to 24*s.*, while Monmouthshire qualities are round 24*s.* Cargo sorts continue to be weak. Smalls are also somewhat weaker at 15*s.* down to 12*s.* for cargo, and even 7*s.* 6*d.* to 10*s.* for other sorts. Pitwood continues to be much prized, and quotations rule up to 75*s.* ex-ship for imported timber and up to 55*s.* delivered at the colliery for home-grown supplies.

The Development of By-products.—It is of significant interest to note the fact that at the first annual meeting of the Monmouthshire and South Wales Coke Oven and By-products Works Association there were represented, as members of the association, 14 important colliery companies who had insured their coke ovens for an output of 1,500,000 tons per annum. Until very recently coalowners in the Welsh coalfields depended entirely upon their coal sales to secure a return on the invested capital. The value of by-products as an adjunct to colliery undertakings did not seem to appeal to Welsh coalowners, and a vast quantity of material was allowed to be wasted. To some extent probably—especially in the best steam coal areas—the unchallenged reputation of Welsh coal had something to do with this neglect. Attention was often called to this neglect, but little was done to bring about a change beyond the erection of a few coke ovens here and there, about the first and most notable being those at the Glamorgan Collieries, in the Rhondda, and later at the Lewis-Merthyr Collieries. It is now, however, realised more and more that this was a mistaken policy; the exigencies of the war have had the effect of accentuating the importance and possibilities of developing the by-products industry on a large scale. This is particularly the case with regard to bituminous coals. In several of this year's colliery company reports references are made to the fact that by-products are being manufactured on a commercial scale. During last year, for example, the Cardiff Collieries started plant for the recovery of benzol and tolulol, while distillation plant has been installed at by-products works of the Powell-Duffryn Company for the recovery of tri-nitro-tolulol. Plant for production of tolulol and concentrated ammonia liquor has been installed at the Resca Collieries, while Messrs. D. Davis, during the past year, have increased their by-product works at the collieries of the Welsh Steam Navigation Company. It will thus be seen that in the Welsh coalfield the recovery of by-products will not continue on a large scale as a post-war industry, but that it will occupy an increasingly important position in the industrial activities in South Wales. By the way, it is a matter of interest to recall the fact in this connection that when Lord Rhondda, the President of the Local Government Board, visited Llwynypia a fortnight or so ago he was presented with an address, the colouring matter for which had been extracted at the collieries of which his lordship was previously the chairman of directors.

Dock Men for the Army.—Something like a stir has been created through a visit of the chairman and military representative of the Local Tribunal to 'Change to confer with shipowners on the subject of releasing men for the Army. Consequent upon the action of the naval and chartering of shipping authorities, the scope for private business in the coal export trade of the Bristol Channel has been very greatly curtailed. The suspension of so large a volume of private trading, with the consequent restriction in the volume of managerial and clerical work, has been realised by the military authorities as affording them an opportunity of calling up for immediate national service many men of military age now in civil employment at the docks. It was suggested by the chairman of Cardiff City Tribunal that an arrangement might be made whereby shipowners, brokers and exporters might agree to some method of amalgamating work on the lines which have been adopted in some instances in the case of tradesmen, whereby the management of one-man businesses has been pooled. The shipowners discussed the matter at length, and decided upon the appointment of a committee to evolve a scheme on the lines indicated. It is understood that colliery proprietors, coal exporters and ship-store merchants will also confer within the next few days on the same subject.

Dock Workers' Wages.—An award was given this week in the case of workmen who have applied for advances in their wages to the Engineers & Shipbuilders Employers' Association, Cardiff, Newport, Barry and Penarth districts. Applications were made by various of the workmen's unions concerned for advances ranging from 5*s.* to 10*s.* per week. The arbitrators—Sir G. R. Askwith, Sir. D. Harrell and Mr. G. S. Gibb—have found in favour of the men, awarding them an advance of 5*s.* per week, and boys 2*s.* 6*d.* per week, the increased rates to come into operation on and after the pay day for the first full pay day in April.

COAL MINE EXPLOSION IN MANCHURIA.—As the result of careful investigations it has been ascertained that the cause of the fire in the Oyama pit of the Fushun coal mine in Manchuria, by which nearly 1,000 men lost their lives, was due to an explosion of coal dust, which was ignited by an open safety-lamp or matches, says the *Japan Chronicle*, as reported by *The London and China Telegraph*. The direct loss occasioned by the destruction of coal and machinery is put at 350,000 yen. It is expected that the pit will be opened again in two months, and in six months half the amount of the usual output—that is 20,000 tons a month—will become available. The usual amount of production will be restored after the lapse of one year. (1 yen = about 2*s.*)

A NEW METHOD OF RENDERING COAL SOLUBLE BY OZONE.—An interesting discovery has been made by Dr. Franz Fischer, who found that if ozone is brought in contact with coal in a glass tube at an ordinary temperature the surface of the coal undergoes a change in so far as it presents a fine brownish bloom, which is soluble in water, yielding a brownish liquid, slightly acid. This discovery led to a test in which 9.6 grammes of coal were exposed to the influence of ozone for 133 hours, when only 0.7 grammes of the original coal was left, so that 92 per cent. was dissolved. The discoverer draws the conclusion from this that the principal component part of the coal is a transformed product of a former cellulose substance which can be rendered soluble by contact with ozone. To judge from the attributes of this new substance it is assumed that the greater bulk is an acid which has been formed by the primary formation of ozonites, which were subsequently decomposed by water. The coal on which this test was made was Westphalian coal.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—Business in Cleveland pig-iron continues on a fairly good scale, notwithstanding that many home consumers, being well placed and not needing to buy for early requirements, are holding off for the present. Some home users, however, are still negotiating on forward account and are prepared to make contracts up to the end of June, subject to any alterations in fixed maximum prices. As there is no dearth of iron the allocations for April are expected to be on a liberal scale. Some sales of forge iron for Scotland for bar making are reported to have been made at the maximum rate. For home consumption No. 3 Cleveland pig, No. 4 foundry and No. 4 forge are all quoted 87*s.* 6*d.*, and No. 1 is 91*s.* 6*d.* Tonnage difficulties continue to hamper business in the export trade, but some improvement is noticeable, and occasional inquiries on behalf of neutral countries are made. No. 3 is 97*s.* 6*d.* and upward for shipment to our Allies, and that price also rules for foundry and forge iron; whilst No. 1 is put at 102*s.* 6*d.* For export to neutral countries the minimum rates named are 105*s.* for No. 3 and 110*s.* for No. 1.

Stock of Cleveland Pig-Iron.—The first change in the stock of Cleveland pig-iron in the public warrant stores since the 21st of last month has been made this week by the withdrawal of 146 tons of No. 3, reducing the quantity held to 2,147 tons, composed of 2,111 tons of No. 3 quality and 36 tons of other kinds of iron deliverable as standard.

Hematite Iron.—There is little new to report concerning the East Coast hematite branch of trade. Production has been reduced to some extent by further changes of a furnace or two on to the manufacture of other kinds of iron, but output is still such as to provide adequate supplies to home consumers and to leave considerable parcels available for export. Nos. 1, 2 and 3 are 122*s.* 6*d.* for home use, 137*s.* 6*d.* for shipment to France, and 142*s.* 6*d.* for export to Italy.

Shipments of Pig-Iron.—Shipments of pig-iron from the port of Middlesbrough, though not heavy, must be regarded as on a satisfactory scale. Clearances this month promise to exceed 60,000 tons. February despatches totalled 40,886 tons, and loadings for March last year were returned at 62,010 tons.

Imports of Foreign Ore.—Fairly large quantities of foreign ore are coming steadily to hand.

Coke.—Local demand for coke keeps heavy, and consequently, though the supply is abundant, values of descriptions needed are upheld at fixed maximum rates, average blast-furnace kinds continuing to command 28*s.* at the ovens, and 30*s.* 6*d.* at the ovens still being named for qualities low in phosphorus.

Manufactured Iron and Steel.—At all the finished iron and steel works there is great activity. The very heavy output is still steadily growing, and it is gratifying to have the assurance that, despite claims for the manufacture of other descriptions, the production of mercantile shipbuilding material shows a marked increase and has now assumed very large proportions. Quotations all round are strong. Common iron bars are 13*l.* 15*s.*; best bars, 14*l.* 2*s.* 6*d.*; best best bars, 14*l.* 10*s.*; iron ship plates, 13*l.* 10*s.* to 14*l.* 10*s.*; iron ship angles, 13*l.* 15*s.*; iron ship rivets, 17*l.* 10*s.* to 18*l.* 10*s.*; packing iron and steel (parallel), 13*l.*; packing iron and steel (tapered), 15*l.* 5*s.*; steel bars (no test), 14*l.* 10*s.*; steel ship plates, 11*l.* 10*s.*; steel ship angles, 11*l.* 2*s.* 6*d.*; steel ship rivets, 19*l.* to 20*l.*; steel boiler plates, 12*l.* 10*s.*; steel joists, 11*l.* 2*s.* 6*d.*; steel strip, 17*l.*; steel hoops, 17*l.* 10*s.*; and heavy sections of steel rails, 10*l.* 17*s.* 6*d.* All the foregoing are quotations to home customers.

Scrap.—There is a moderate business passing in scrap, but some reductions in prices have been made. Heavy wrought-iron scrap (½ in. and over) is down to 5*l.* 5*s.*; heavy wrought-iron scrap (⅜ in. and over) has fallen to 5*l.* 15*s.*; and wrought-iron plates (⅜ in. and over) have been lowered to 6*l.* 5*s.*; whilst 10*l.* has been fixed as the maximum price for second-hand re-layable rails.

Cleveland Miners and War Bonus.—The council of the Cleveland Ironstone Miners and Quarrymen's Association have decided to claim 1*s.* per day war bonus for all men above 18 years of age, and 6*d.* per day for boys under 18 years of age, regardless of any increase in wages which may accrue as the result of the selling price of pig-iron. The claim is to be placed before the mine owners at as early a date as possible, and failing a satisfactory settlement the Ministry of Munitions is to be approached as the authority responsible for the present maximum price of pig-iron, which has the effect of restricting the wages of miners. The council have further ordered that, should such negotiations fail, an appeal be made to the Miners' Federation of Great Britain for their assistance in the matter.

Ironstone Miners and Overtime.—The Cleveland ironstone miners are seeking a definite understanding with the mine owners regarding overtime for mechanics, and claiming a basis of six-hour shifts in the mines and seven hours on the surface.

PERSONAL.—The Aeronautical Society of Great Britain has now removed to its new offices, 7, Albemarle-street, Piccadilly, W. 1. The telephone number is Gerrard 7373, and the telegraphic address "Didaskalos, London."

THE RUNNING BALANCE OF PROPELLERS AND THE VIBRATION OF SHIPS.

Some Experiments on the Influence of Running Balance of Propellers on the Vibration of Ships. †*

By MR. J. J. KING SALTER, R.C.N.C.

THE vibration of ships has been the subject of many papers and much discussion, but, so far as the author's knowledge goes, it does not appear that the particular question of the action of the propellers themselves, in so far as the effect of their running balance has upon vibration, has been previously brought forward. The object of the present notes is to present the results of some experiments on this point carried out by the author in the course of his work as General Manager of the Commonwealth Naval Dockyard at Sydney, Australia, and which the Australian Naval Board has granted him permission to submit to this Institution. Since the introduction of turbines in warships as the main engines, running at much higher revolutions than was previously the case with reciprocating engines, the necessity of seeing that the propellers were suitable, not only as regards their form, but also as regards their being in proper mechanical balance, has naturally received considerably more attention.

The experiments to which reference will be made were carried out in two destroyers and a Town class cruiser, which were being built at the Commonwealth Naval Dockyard. In the case of the destroyers, it may be of interest to observe that the turbine engines and the propellers were the first of their kind to be built in Australia, and that, consequently, every care was taken that they should be as perfect as possible.

On test in the shops, under steam, the turbines ran as free from vibration as any one could wish or expect, special care having been taken in their manufacture to ensure the rotors being in as perfect running balance as possible, the means adopted to do this being first to balance each rotor on knife-edges to obtain a static balance, and subsequently to mount it on spring bearings, so arranged that the rotor in its bearings was free to move up and down vertically, but not sideways, and then rotating the rotor in its bearings at speed, and by removing weight at the end as found necessary till the rotor ran in its spring-mounted bearings without a perceptible tremor, thus ensuring what may be called dynamical balance. No claim is made for any novelty in these methods as regards the rotors, but it is mentioned on account of what follows in regard to the subject-matter of this paper.

The usual and most recent practice as regards the manufacture of the propellers for the destroyers was followed, viz.: After being cast, the driving faces were machined to true helices, and the backs chipped and filed to ensure as uniform and as accurate a shape as possible, sections being carefully calibrated at frequent radii and made to agree with the designed thickness at each point of calibration, and then statically balanced on knife-edges, not between lathe centres, as it was considered and found that knife-edges were more sensitive; and, finally, the whole surfaces were buffed to a smooth polish.

The first destroyer to be completed with the Australian built engines and propellers, made as described above, ran her trials very satisfactorily, but there was a certain amount of small vibration in the vessel, most pronounced right aft above the propellers, of which there were three—one on each of three shafts. The vibration extended right through the vessel, very much diminished forward, but sufficient to cause the hand rails and other fittings in the engine room and fore bridge to shake, being more pronounced on the fore bridge. That this vibration was due to the main engines was considered most improbable, as these latter apparently ran as smoothly and as free from vibration as they did in the shop test. The other only rotating masses that could possibly be supposed to cause vibration were the propellers.

Was this vibration due to the propellers working in the water with possible interference with each other, and other water causes, or was any of it due to the propellers themselves not being in perfect running balance? The question then arose, were the propellers, as manufactured, fulfilling the conditions for perfect running balance which, quoting from Mr. Barnaby's book on "Marine Propellers," are given to be:—(1) Each blade must be of the same weight; (2) the centre of gravity of each blade must be at equal distance from the axis of the propeller; (3) the centre of gravity of each blade must lie in a plane at right angles to the axis. To fulfil these conditions, each part of each blade must be exactly the same shape, the same thickness, and be symmetrically situated around the axis. If this is so, then condition (3) ensures that each blade is similarly placed along the axis.

There is no way known to the author for conditions (1) and (2) to be obtained, except by care in casting, marking off, and machining the driving faces, hand chipping and filing the backs, and calibrating sections at frequent intervals to given dimensions. If this was carried out exactly, condition (3) would be naturally satisfied. But in practice it is practically impossible to ensure that all parts of each blade shall be exactly of the same thickness, and that all parts of the propeller are exactly and symmetrically disposed around and along the axis.

What check can there, therefore, be exercised to know whether condition (1) is exactly satisfied? Balancing the propeller on knife-edges does not ensure that either condition (1) or (2) is satisfied, as it is possible for the propeller to be in static balance, and yet for these two conditions not to be fulfilled, and, so far as the author's knowledge goes, he does not see what other method can be adopted to place an absolute check on these two conditions. As regards condition (3), hitherto, also, so far as the author knows, no other check other than the static balance and the calibration has been exercised to prove whether this condition has been fulfilled, and it has apparently been assumed that the above checks have been satisfactory.

The object of this paper is to show that there is another check to which propellers can be subjected, viz., dynamic balancing, *i.e.*, the rotating of the propeller at speed on spring bearings, noting the vibration, and the removal of weight from certain parts of the blades and even the boss, the position of which is indicated by the direction in which the vibration acts, in a manner exactly similar to the way in which a turbine rotor is balanced, as mentioned above. It is contended that by this further balance a perfect running balance can be obtained, *i.e.*, one in which the propeller can be made to rotate at any speed in the spring bearings without a perceptible tremor, and presumably, if it will do this in a live bearing, it will similarly run without vibration on its shaft in the ship. Condition (3) is thus satisfied, and also that the mass centre of the propeller coincides with centre of rotation, but it does not in any way help to satisfy conditions (1) and (2), and, as previously stated, so far as it can be seen, the approximate satisfaction of these two first conditions can only be obtained by careful and accurate workmanship.

As previously stated, if conditions (1) and (2) were exactly fulfilled, and the propeller otherwise also accurately made, condition (3) would follow; but that it does not, has been proved by the tests carried out, every propeller so far tested—some twenty-five have been dynamically balanced—not one was without considerable vibration. Some of these propellers were made at the Commonwealth Naval Dockyard, and others have been supplied by various contractors, all of which latter were built under Admiralty supervision and conditions, so that it may not be far wrong to assert that there is probably hardly a propeller made which, if subjected to the dynamical balancing test, would not be subject to vibration.

It is thought that a little consideration will show that this is probably the case, as it is practically impossible to ensure that every part of each propeller is exactly symmetrical, when such accuracy depends so largely on hand work to measurements; and, moreover, there is the added possibility of a difference in density in the material, and also the great difficulty at the roots of the blades and at the boss of ensuring absolute uniformity, but, by utilising the centrifugal forces developed when the propeller is rotated, all these discrepancies at once manifest themselves, and with a little care and experience they can be practically entirely eliminated.

It might be supposed that, in the short fore and aft length, such as the average propeller has, the magnitude of the forces about the plane at right angles to the axis would not be great enough to cause much vibration, and that it would not appreciably affect the ship, but the result of the experiments carried out, referred to below, in two destroyers and one larger vessel—a Town class cruiser—show that they do have a very considerable effect. That this may be so will be readily understood, when it is remembered how great are the forces developed by small weights under centrifugal forces, acting at the speeds turbine-driven propellers have hitherto been run.

It is well known to be unnecessary for running balance that any number of weights, disposed rigidly around a shaft, shall be of equal weight, nor that their centres of gravity shall be at equal distance from the axis of rotation, but such a system will only rotate in dynamic balance when condition (3) is fulfilled. The conditions for such balance may be found in treatises on statics and dynamics, but reference is specially made to a book by Professor Dalby on "The Balancing of Engines," 1902, page 13 *et seq.* It may be of interest to note the importance attached to the practice of balancing railway carriage wheels referred to in Professor Dalby's book (*vide* page 19), which balancing is practically the same as here proposed for propellers. The dynamical balance does not, therefore, provide a perfectly balanced propeller, as defined by Mr. Barnaby, but it does provide for one that will rotate without vibration if the balancing is properly carried out. Clearly, if a propeller will vibrate when tested in the shop, such vibration must be transmitted to the ship.

All the propellers hitherto dynamically balanced by the author have been those which had been completed and passed as satisfactory, but in future, in making new propellers, it is proposed, after the shaping of the blades and calibration have been completed, to dispense with the statical balancing, and proceed with the dynamical balance straight away, as the tests carried out in that balance would show whether the out of balance was due to the mass centre being excentric, or whether it was due to condition (3) not being fulfilled. Once the balancing apparatus is provided, it can be safely asserted that the time and cost required to build a propeller will not only be less, but the result will be far more satisfactory, as hitherto the time taken to balance a propeller on the knife-edges has been considerable. The next point to determine was how much would elimination of vibration in the propeller affect the ship. To do this it was necessary to have an instrument that would record the small quick vibrations, but take no account of any of the pitching and rolling motions of the vessel when in a seaway.

At the time the first set of dynamically balanced propellers were tried in one of the destroyers, the author, unfortunately, had no instrument available which would do what was required. A Schlick vibrometer was tried, but in these light vessels, and in an open seaway—no

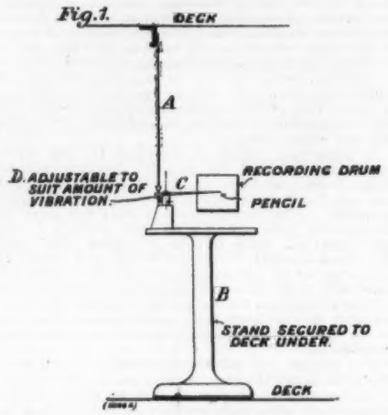
* Paper read before the Institution of Naval Architects, March 29, 1917.

† Proof uncorrected by author.

smooth water being available—this instrument, when adjusted sensitively enough to record the small vibrations, was so affected by the pitching that no satisfactory results could be obtained. It can only, therefore, be asserted that in the opinion of the ship's and Dockyard officers—and of the author—there was a decided improvement. The shaking of the hand rails in the engine-room and on the fittings on the bridge had been practically eliminated, and the vibrations aft were considerably reduced.

The author would not have attempted to put forward these remarks had he not something more definite to rely upon than personal opinion, and it was in the subsequent experiments on the Town class cruiser, which was being built at the Dockyard, that he was able to obtain a permanent record of the difference in vibration between two sets of propellers, as made by one of the leading specialist manufacturers of propellers in England, the one set being tried on the ship as supplied by the makers,

Fig. 1.



and the other after being dynamically balanced by ourselves. By the time this vessel was ready for her trials, the author had, after much consideration, evolved a very simple means of obtaining a definite record by an instrument which, although it did not give absolute readings of the vibration of any one particular part of the ship, yet gave definite differential readings of the vibration of two parts, which were readily comparable under the two conditions, and which were, for the purpose required, entirely free from the effect of the vessel's movements in a seaway. The principle of the instrument depended upon recording the difference of vibration of two decks, one immediately over the other. It was anticipated each deck would, owing to their different stiffnesses, have a different amplitude of vibration, and that if stiff rods were fixed one to one deck, and the other to the deck over, and pointing to meet one another, and slide over one another at their junction, the relative movements of the two rods, repeating the movements of the decks, could, by means of a simple lever, be magnified and recorded on a drum worked by clockwork.

A diagrammatic picture of the principle of the arrangement is shown in Fig. 1; while Fig. 5, Plate XXIV, is a photograph of the actual instrument. Referring to Fig. 1, the two rods are represented by the rod A, and the standard B, both of which move with their respective decks, being secured thereto. The multiplying lever is shown at C, and the recording drum, worked by clockwork, is seen under the end of the lever C. It was, however, a matter for conjecture as to what would be the amplitude of the vibration to be recorded. The leverage of the recording lever was, accordingly, made adjustable, so that multiplication of the actual movements of the decks could be varied from 50 to 1 to about 5 to 1, by adjusting the length D. It was found that a ratio of 25 to 1 gave good readings, and was sufficiently sensitive to show the smallest vibrations. A speed of paper of about 30 in. per minute was also found suitable.

Fig. 2, annexed, shows a record for the vessel in a moderate swell, rolling about 9 deg., and pitching slightly, but with the main engines stopped. On the original record, if examined by a magnifying glass, the vibration due to the auxiliary engines, which were running, can just be seen, and the tremors shown in one part of the curve are due to the crew leaving the deck at a run after being mustered. And the undulating form of the curve shows the action of the decks due to rolling and pitching. This undulation can be seen in the other records with the main engines running, but it evidently does not affect the rapid vibrations, of which a record was required.

The instrument was put up in the captain's cabin, approximately over the aftermost pair of propellers, of which there were four, one on each of four shafts. The deck over was the upper or weather deck, and the deck under was the protective deck. This latter deck was, by the nature of its structure, very stiff, and, by its position nearer the neutral axis, less liable to vibration than the upper deck. The instrument recorded, therefore, only the relative movements of these two decks, so that readings of the vibrometer would tend to be either more or less than the real movement of either deck, according to their relative motions.

The readings might be the sum of the movements of the two decks, or their difference, but this did not, it is considered, impair the results aimed at, viz., to obtain relative records between vibrations set up by the two sets of propellers—the one only statically, and the other also dynamically balanced.

The trials of this vessel were being carried out with a view to completing her as soon as possible, and, being under war conditions, no time was available to make special sea trials, but such results as were obtained were sufficient to show the very marked difference between the two sets of propellers. In order that the conditions for vibration might be the same, the loading of the vessel in the two conditions was maintained as similar as possible, so that the draughts were practically the same.

These results, as graphically recorded, are given,* and Fig. 3 shows the curves deduced from the records obtained. In Fig. 3, subjoined, the upper curve A shows the maximum readings obtained with the unbalanced propellers. It will be observed how, at

Fig. 2. MAIN ENGINES STOPPED, VESSEL ROLLING 9 DEGS. FULL AMPLITUDE.

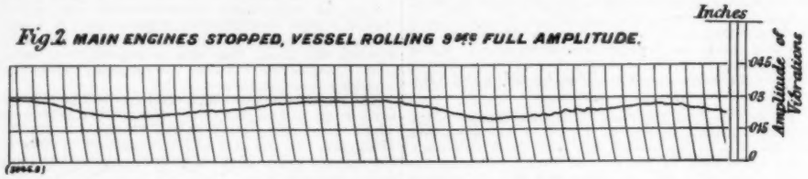


Fig. 3. VIBROMETER RECORDS.
VESSEL FITTED WITH 4 PROPELLERS.
CURVES A. PROPELLERS STATICALLY BALANCED.
TAKEN ON 25,000 & 22,000 S.H.P. TRIALS 4-11-16.
CURVES B. PROPELLERS STATICALLY & DYNAMICALLY BALANCED.
TAKEN ON COMMISSIONING TRIALS 4-12-16.

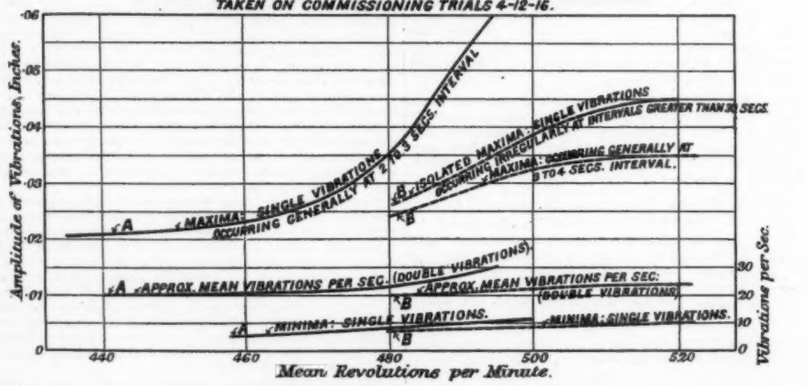
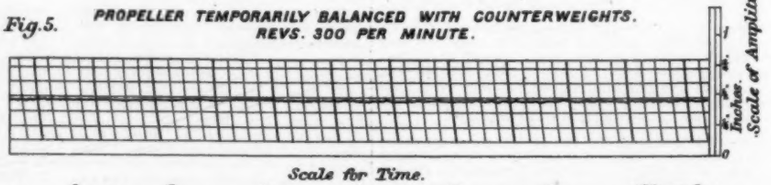


Fig. 4. VIBROMETER RECORD OF TEST OF PROPELLER IN THE SHOP ON THE BALANCING MACHINE. PROPELLER AS SUPPLIED. REVOLUTIONS 300 PER MINUTE.

Fig. 5. PROPELLER TEMPORARILY BALANCED WITH COUNTERWEIGHTS. REVS. 300 PER MINUTE.



the highest speeds reached, viz., about 493 revolutions, the vibrations increased at a rapid rate, whereas in the upper curves B B the maxima were not only much less but of a different character. In the A curves, periods of relatively intense vibration, alternating with periods of comparative small vibration, occurred at frequent but varying intervals, whereas in the curve B these periods of intense vibration had become so much reduced as to be almost absent, occurring only at long intervals. The periods of intense vibration felt to the observer quite severe, and were sufficient to cause any objects lying on the cabin table to rapidly dance off, whereas, with the balanced propellers, such objects remained on the table. It may also be of interest to observe how very small the total amplitudes of vibrations really were, *vide* Fig. 3.

It will be noticed that the maximum revolutions with the balanced propellers were higher than with the unbalanced. The greater part of this increase was no doubt due to the stokehold party providing more steam, but it is not unreasonable to assume that some of this increase was due to the propellers working under better balance, and, if this was so, a small increase of speed would result, as when a set of propellers, each weighing nearly two tons, even in such a comparatively small vessel as the one in question, are sufficiently out of balance as to vibrate considerably when tested in the shop in the spring bearings before being balanced, and when such propellers are working in the ship, setting up vibration, it is very evident that such vibration not only must cause extra friction in the A bracket bearings, and thus tend to reduce the revolutions and general efficiency of the propellers, but must also increase the wear and tear in those bearings, and also in other fittings in the ship generally.

The rates of revolutions given on the records are the mean of the four shafts. The variation from the mean at 493 revolutions amounted to about 15 above and 15 below. This in itself is a probable source of vibration. It will be noticed that the rate of the vibrations recorded increased slightly as the speed increased, and at the higher speeds was about 25 per second, whereas the maximum of each propeller on test in the shop was about 10 per second.

It will, it is considered, be admitted that the impressions and assertions of so many persons in the case of the destroyers, and the evidence of the records obtained in the case of the cruiser, cannot be a mere coincidence, and if the author has succeeded in showing that to obtain the best results and to effect perfect running balance it is necessary dynamically to balance propellers, and, so far as he can see, that such balance is unobtainable otherwise, he will rest satisfied, observing, in a time like the present, when our Navy is undergoing such a severe ordeal, and when our ships are running so constantly at full speed, that anything that can be done to reduce vibration must help considerably to reduce the fatigue of the officers and men, who are now being strained to their uttermost limit. As the author can safely say, he would personally have

*[We regret the pressure on our spaces prevents us reproducing these graphic records.—Ed. E.]

TABLE I.—RECORD OF BALANCING OF PROPELLERS DYNAMICALLY.

Propeller.				Metal Removed in Ounces. Radius in Inches.				Approximate Amplitude. Maximum Vibration.
——	Diameter.	Pitch.	Weight.	No. 1 Blade.	No. 2 Blade.	No. 3 Blade.	Boss.	
Destroyers.	ft. in.	ft. in.	cwt.					
M 469	4 10	4 6	10	131 at 15	16.5 at 17	83 at 21	Nil	0.109
S 469	4 10	4 6	10	102 ,, 20	38 ,, 21	95 ,, 14	Nil	0.105
P 469	4 10	4 6	10	13.4 ,, 15	5.1 ,, 24	11.9 ,, 15	Nil	0.04
2691/13	4 10	4 6	10	13 ,, 20	Nil	14 ,, 17.5	6.5 at 5.5	0.042
2621/6	4 10	4 6	10	16 ,, 18	9 at 18	10.5 ,, 17	Nil	0.062
2699/14	4 10	4 6	10	13.5 ,, 18	11 ,, 18	15.75 ,, 15	Nil	0.02
2671/11	4 10	4 6	10	21.8 ,, 20	34.8 ,, 15	Nil	5.4 at 6	0.032
2601/4	4 10	4 6	10	7.1 ,, 20	17.4 ,, 18	19.3 at 18	9.8 ,, 5.5	0.046
2680/12	4 10	4 6	10	33.6 ,, 16	11.8 ,, 21	21.7 ,, 18	5.6 ,, 5.5	0.07
2604/4	4 10	4 6	10	Nil	5.2 ,, 17	9.7 ,, 17	Nil	0.03
2633/7	4 10	4 6	10	36.1 at 17	58 ,, 18	16.5 ,, 22	30 at 5.5	0.072
90 RH	4 10	4 6	10	106 ,, 18	75 ,, 19	114 ,, 19	82 ,, 5.5	0.187
2646/8	4 10	4 6	10	42 ,, 14	84 ,, 17	Nil	21 ,, 5.5	0.031
2704/15	4 10	4 6	10	32 ,, 20	19 ,, 18	67 at 16	41 ,, 6	0.0625
95 RH	4 10	4 6	10	55 ,, 18	Nil	67 ,, 18	34 ,, 6	0.093
470 RH	4 10	4 6	10	40 ,, 16	34 at 18	3 ,, 15	40 ,, 6	0.0625
469 RH	4 10	4 6	10	45 ,, 19	1 ,, 13	40 ,, 17	47 ,, 6	0.031
89 LH	4 10	4 6	10	Nil	103 ,, 16	84 ,, 19	67 ,, 5.5	0.125
Cruisers.								
1 RH	7 4	6 5	38	50 at 27	Nil	48 ,, 27	30.8 ,, 10.5 73 ,, 11.5	0.218
2 RH	7 4	6 5	38	Nil	11.8 at 27	29.9 ,, 27	38.7 ,, 10.5 77.1 ,, 11.5	0.187
1 LH	7 4	6 5	38	17.1 at 24	33.4 ,, 27	Nil	7.4 ,, 10.5 42.5 ,, 11.5	0.156
2 LH	7 4	6 5	38	Nil	83.3 ,, 26	49.8 at 27	58.9 ,, 10.5 156.7 ,, 11.5	0.312
Starboard wing	7 4	6 5	38	Nil	48.2 ,, 26	28.2 ,, 23	Nil	0.21
Port wing ..	7 4	6 5	38	158 at 25	Nil	26 ,, 28	Nil	0.76
Port centre ..	7 4	6 5	38	Nil	30 at 23	Nil	38 at 10 70 ,, 12	0.2
Starboard centre	7 4	6 5	38	Nil	Nil	Nil	80 ,, 11.5	0.47

been very sorry to have had to live in the captain's cabin when steaming at full speed with the unbalanced propellers, whereas with the others, although there was still not an inconsiderable amount of noise and vibration, yet the two conditions were so totally different, one of the officers of the ship, without stopping to think, exclaimed: "It is quite 100 per cent. better," and the author can only say he wished it had been quite so perfect.

In the Appendix are given illustrations of the balancing apparatus in use at the Dockyard, also views of one of the cruiser's propellers, showing where weight requires to be removed, together with a description of the general principles of the procedure to be adopted, observing that any one who has not had experience in balancing a turbine rotor or similar article, may not find it quite so easy to know where to remove weight. In any case, some experience is required, and hitherto a certain amount of systematised guesswork was also necessary; but it is anticipated with the use of the vibrometer records that it will be possible, from these records and the known weight of the propeller, to be able to predict how much weight has to be removed. Particulars are also given, in Table I, of the weights removed from a few of the propellers dealt with, including those of the cruiser, from which latter the records for this paper were obtained.

APPENDIX.

Fig. 7, Plate XXIV, shows the apparatus employed for dynamically balancing propellers. It was built originally for balancing turbine rotors. This view does not by any means show an appliance about which the last word has been said. It is, on the contrary, only the first of its kind, erected from plant more or less available and adapted to the purpose required, and there is much room for improvement, though it has served its purpose very well. It will be seen to consist principally of two stands, with two bearings over, mounted on plates, under which latter one or more springs are inserted, the number and strength of the springs being varied to suit the weight of the article being treated. The bearings on their springs can move up and down vertically, but are constrained from any horizontal movement. It is driven by a 65 h.p. electric motor, through a length of shafting with Hooke joints at each end. The weight of the propeller and other fittings, as the case may be, is thus supported on the springs, and if the fitting is out of balance on being rotated, it oscillates up and down on the springs.

The propeller being mounted as described, it is rotated, and the direction relative to the shaft, in which the vibration is acting, is marked on the shaft, as it rotates, by a pointer, one at each end, fixed to the base, and screwed up till it just touches the shaft, which has been smoked to make the marking clear. The marks obtained circumscribe more or less of the shaft, depending upon the extent of the vibration. When this is large, the marks are short, but when there is hardly any vibration, the marks nearly circumscribe the shaft. From the positions of the marks it is ascertained where temporary weights are to be bolted on to the ends of the boss to balance the excess of metal on the propeller. After these have been put on, another trial is made, and the weights adjusted till the balance is correct. There are no means of saying how much temporary weight has to be put on. This has hitherto had to be determined entirely by guesswork, and by the experience of the tester. It may be of interest to note that a weight of only 1½ lb. at a radius of 12½ in. was sufficient to cause a propeller, weighing 38 cwt., and revolving at 180 revolutions, to vibrate with an amplitude of 0.42 in. in the testing machine.

One of the four cruiser propellers, received from the contractors, was rotated at 300 revolutions per minute before being balanced. It vibrated to a considerable extent, viz., about ¾ in. up and down (Fig. 4). This was a particularly bad case. In Fig. 8, Plate XXIV, the disc of the vibrometer is seen to be vibrating considerably in front of a black ground. Having obtained the correct balance, weight corresponding in leverage to the temporary balancing weights has to be removed from the blades as opposite to the position of the balancing weight as possible, and at the same end (fore and aft) of the blade as the balancing weights. Fig. 5 shows the results got when the propeller was temporarily balanced with counterweights.

Fig. 9, Plate XXIV, shows a cruiser propeller with its balancing weights A and B, and the places on the blades from which the weights of metal, as marked thereon, have to be removed. This view is looking towards the machined driving face, and the white patches, showing the parts of the blades whence weight has to be removed, have been shown on that face for pictorial purposes, but the actual metal will be taken off the backs of those blades. A and B are the positions of the temporary balancing weights, and on blade 3 it is seen how the weight to be removed is opposite to A, and at the same end of the propeller. And on blade 2 the weight there shown is opposite to the weight B. It will be noticed that the weight to be removed on blade 2 is in excess of that on blade 3. This is due to the propeller being also out of statical balance. After the removal of the metal, the propeller is tested again, and, if necessary, after treatment yet again, till it will run true without perceptible tremor.

A list of particulars of weights of metal removed from some of the propellers treated is given in Table I; as regards the last four cruiser propellers on the list at the moment of writing, time had not permitted of the metal being removed, so that the weights given are only approximate.

APPARATUS FOR DETERMINING SHIP STABILITY.

*Description of an Apparatus for Interpreting Stability for the Use of Shipmasters.**

By MR. THOMAS GRAHAM, B.Sc., R.C.N.C. (Temp.).

1. THE object of this paper is to describe a simple apparatus whereby the stability of vessels under any ordinary conditions of loading can be shown graphically, and easily interpreted by shipmasters and others to whom the subject is of practical importance. In 1911 Mr. S. B. Ralston read an interesting paper before the Institution describing his indicator for determining initial stability and trim, and the subsequent demand for the apparatus is a clear indication of the growing attention which is being bestowed upon the question of stability by both the owners and captains of ships. The apparatus now to be described has been designed to co-ordinate and employ more fully the existing information supplied to vessels, namely, draught, deadweight and displacement scales, metacentric diagram, and stability results.

2. Briefly, to recapitulate procedure and to provide a working example, the calculation for the metacentric height of a vessel in the load condition is as given in the tabular statement in the next column. In this summary the cargo forms the heaviest item of the deadweight, and, as usual, is assumed to be homogeneous, the centres of gravity being reckoned coincident with the centres of volume of the spaces containing it. The result admittedly applies to only one type of cargo and stowage, and in the majority of cases this varies from voyage to voyage. The object, therefore, is to devise a system which shall so co-ordinate and adapt the information available to shipmasters, as to render it applicable not only to one particular form of the table below, but to an infinite number of variations of it representing the conditions for all cargoes, homogeneous or otherwise.

Item.	Weight in Tons.	V.C.G. above Keel in Feet.	Moments in Foot-tons.
Ship in light condition ..	3,900	21.3	83,000
Coal	1,000	17.0	17,000
Cargo	3,500	20.8	73,000
Crew, stores, fresh water, &c.	50	25.0	1,200
Reserve of feed water ..	100	2.0	200
Load condition of ship ..	8,550	20.5	174,450

Height of transverse metacentre above keel = 22.3 ft.
Height of C.G. above keel = 20.5 ,,
"G.M." = 1.8

3. To effect this by the method proposed, two assumptions are made:—(1) That each compartment into which cargo is placed is filled by that cargo to the underside of beams, in order that the centre of volume of the hold or 'tween deck may always represent the centre of gravity of the cargo. (2) That the cargo placed in each space is homogeneous, though not necessarily homogeneous throughout the ship. In the majority of vessels another approximation is justifiable. The heights of the centres of volume of the holds throughout the ship vary so little, that an average height may be assumed for them all. In three typical cases the heights above keel of centres of volume of holds are as follows:—

——	1. Passenger and Cargo Vessel. Length 400 ft.	2. Cargo Vessel. Length 370 ft.	3. Cargo Vessel. Length 320 ft.
	ft.	ft.	ft.
No. 1 hold (forward)..	14.1	17.5	17.4
No. 2 hold (forward)..	13.4	15.8	16.0
No. 3 hold (aft) ..	13.2	15.5	15.6
No. 4 hold (aft) ..	13.7	16.7	16.5

No serious error, therefore, is involved in these and similar cases by taking an average height for all the holds. The 'tween decks can be similarly dealt with. By doing this, work is greatly reduced, as with the conditions laid down in the second assumption, the total moment of cargo about the keel is directly proportional to the total weight of cargo, irrespective of the density of the cargo in separate holds or 'tween decks.

4. The chart shown on Fig. 1, Plate XXVI, embodies a draught and deadweight scale and a curve of transverse metacentres—information which is supplied for practically every vessel.

A is a scale of weights set up in any convenient units of length, ranging from the lowest to the highest probable amount of cargo which any compartment, or group of compartments similarly situated with respect to height, is likely to accommodate when full. In this case the lower limit is 800 tons and the higher 1,550 tons, the former figure being reckoned to underestimate the lowest weight of cargo which the smallest group of compartments (lower 'tween decks) will ever carry, and the latter figure exceeding what can reasonably be supposed to be the maximum contents of all the holds. Adjacent to table A is a series of other columns designated "holds," "lower 'tween decks," "upper 'tween decks," and "coal." These contain scales of moments about the keel, of the cargo in the respective compartments corresponding to the concomitant weight values in table A. Thus, if 1,450 tons were placed in the holds, the moment of that weight, namely 18,200 ft.-tons, is obtained in the corresponding "holds" column. Similarly, if 900 tons and 1,200 tons were put into the lower and upper 'tween decks respectively, the corresponding moments are 18,650 ft.-tons and 34,600 ft.-tons. And so if all the items of deadweight be observed and summed in this way, the total moment of the deadweight about the keel for any distribution of cargo, is known.

5. For work of this kind the values of the moments are represented with a reasonable degree of accuracy by the first three significant figures, and in consequence the values in the columns of moments have been expressed in thousands of foot-tons. This, too, eliminates figures of high magnitude from the chart, which is desirable.

6. C C, Fig. 1, Plate XXVI, consists of two similar scales, one of which is fixed and the other adjustable. A cursor is supplied for use in conjunction with these scales, in construction similar to that used on the ordinary slide-rule. The order of magnitude of the graduations on the scales being the same as that representing the moments in the columns (*i.e.*, moments multiplied by 10^{-3}), the summation of the moments is rendered automatic. Thus, if as before 1,450 tons be placed in the holds, the moment is 18.2. Place the origin of the sliding scale at 18.2. Next 900 tons are put into lower 'tween decks giving a moment of 18.65. Move the cursor to 18.65 on the sliding scale and read off 36.85 on the fixed one, and so on, the process of summation being continued until the full load is on board, which, to pursue the example taken, might be 4,500 tons with a moment of

* Paper read before the Institution of Naval Architects, March 28, 1917.

90.0. Stores, fresh water, and reserve feed water having a small moment in the case cited, have been included in the light weight of the ship. It may be noticed that the inclusion of water ballast, if carried in the double bottom, may be treated solely as an increase in dead-weight, the relatively small moment about keel being neglected.

7. The curve D D is displacement curve plotted logarithmically about the datum line x x, and S S is a scale graduated logarithmically to the same unit as the curve. This scale can be adjusted so as to facilitate the reading off of deadweight and moments at any draught, and also can slide in the direction of the ordinate of the displacement curve, so that the operation of division can be performed logarithmically.

8. Up to this point nothing has been said of the light ship and its moment about keel. The latter is allowed for in the scale S S. Thus, in the example taken, it was found that the total moment of the 4,500 tons of dead-weight was 90.0, but the corresponding 90.0 on S S is arranged to represent 90.0 + 84.45, the total moment for the light condition. Hence, if this 90.0 on S S be placed coincident with the displacement curve at the draught for 4,500 tons of deadweight—namely, 25 ft.—the height of G above keel will be indicated on S S at the datum line x x, since log-moment—log displacement gives the quotient in feet on a log. scale. Then from the adjacent locus of metacentres the G M can be obtained. For the convenience of deducing the results at intermediate conditions such as those in which the coal is 25 per cent., 50 per cent., or 75 per cent. consumed, the "coals" table provides the weights and corresponding moments at these percentages, which will be deductions from the total weight and moment.

9. The whole operation is simple and accompanied by a degree of accuracy not much inferior to that which would be obtained by working out the results in the ordinary manner in a designing office. As a rule vessels are chartered for definite shipments, so a chart of this kind would be employed in the harbour of loading and the operator would have to concern himself only with observations of the draught and consultation of the dead-weight scale.

10. For the purpose of interpreting the stability of ships at various angles of heel the indicator shown diagrammatically in Figs. 2 to 5, Plate XXVI, has been devised. This instrument illustrates three features of stability which are of most practical importance, viz.:—(1) An automatic record of the variation of the righting arm as the ship heels over from the upright to the vanishing angle. (2) The approximate angle of heel at which the freeboard deck edge becomes awash. (3) The position of the water-line throughout the range of moderate angles met with in practice.

11. T is a plane wood lamina representing the midship section of the vessel to any convenient scale, say ½ in. to the foot, which can pivot about the point A in a vertical plane. On a protractor surmounting the section, degrees are marked off with respect to A as origin, so that as the section is displaced from the upright, the angle of heel is indicated by the pointer h.

12. On the centre line is a scale of feet graduated from the keel upwards, and a brass pointer P moving in a slot can be adjusted to any particular height on the scale. A plumb-line, consisting of a silk thread with small brass weight attached, indicates the line of action of gravity of the ship at all angles of heel when hung over the pointer, the latter having been adjusted to the height of centre of gravity above keel as determined by the use of the chart. M is a brass plate whose curved edge represents the metacentric evolute for the given draught and displacement. It has the form as shown. On the section two screw spigots are fitted which pass through H H holes drilled in the plate, and receive small nuts which fix the evolute rigidly to the section. Arranged to pass over the edge of this evolute is another plumb-line similar to the one described, and as it must always hang tangentially, the thread will be coincident with the vertical through the corresponding centre of buoyancy for any angle of heel and will consequently represent the line of action of the buoyancy. The distance between the two threads thus shows to scale the magnitude of the actual righting lever at all angles of heel, and for the purpose of observing this dimension a small scale of feet is attached to the gravity thread.

13. With regard to the plate M; as the metacentric evolute changes with change of draught, a series of these plates is supplied for any particular vessel, each plate representing a mean evolute over a relatively small interval of draught. It is found in normal forms of ships that 12 in. is a suitable interval, and the total range of draught which the supply covers extends from the lightest "arrival" condition (*i.e.*, with all coal consumed and a cargo load in accordance with the lowest scale laid down in the deadweight columns on the chart) to the freeboard condition. To facilitate ready adjustment each plate has the interval of draught to which it corresponds engraved on it thus (23–24), (24—25), or (25—26), as the case may be (see Fig. 2a annexed).

14. The feature of the apparatus remaining to be described is the arrangement for indicating the position of the water-line at moderate angles of heel. The point A, Fig. 2, Plate XXVI, about which the section pivots is a mean position of the centre of curvature of flotation, the question of the fluctuation or assumed permanency of which is discussed in a subsequent paragraph. B B is a horizontal beam passing through a slot in the standard supporting the section, and capable of vertical adjustment to any required draught when the section is in the upright position. A thread connecting the extremities of B B stretches across the face of the section so as to represent a water-line. Then, having adjusted B B so that the thread coincides with the particular draught before inclination, and assuming that the curvature of flotation is an arc of a circle up to angles of 30 deg., the thread will indicate the position of the water-line as the ship is displaced through this range of angles.

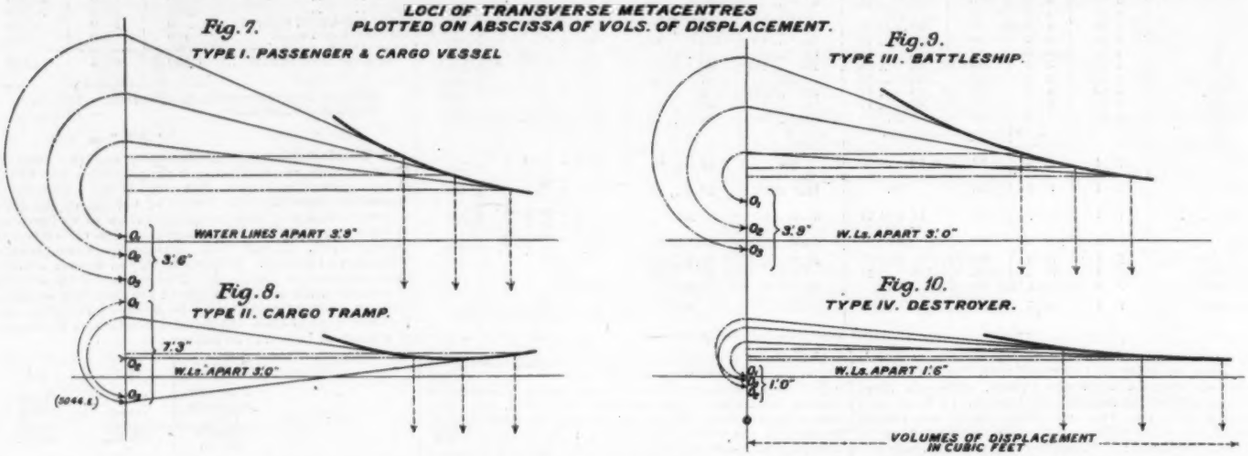
15. Reverting to the point A; in many forms of vessels the C.C.F. (centre of curvature of flotation) for successive draughts between the "arrival" and deep-load conditions varies so little in absolute height that a mean fixed position can be allocated to it. This greatly facilitates construction and working of the apparatus (see Fig. 6). In many other forms of vessels, however, especially in cargo ships, the absolute height of C.C.F. varies considerably, and therefore an adjustment of the point A becomes necessary to secure greater accuracy of results. Figs. 3 to 5, Plate XXVI, illustrate the adjusting device. A guide a a fixed to the back of the section accommodates a sliding piece d which can be adjusted to any required height by a screw and nut arrangement working in a slot n n in the guide. A pin f of square section fits into a swivel-piece g attached to but free to rotate in the vertical post of support, and the pointer h keyed to g indicates degrees of heel on the protractor already referred to.

16. The actual adjustment of A is controlled by a gauge as shown in Fig. 3, which indicates the mean position of the C.C.F. over each of the 12-in. intervals of draught for which the M plates are provided. Thus, if a vessel were floating at a draught of 24 ft. 6 in. the M plate marked (24–25) would be placed in position and the slide d adjusted until its top edge were coincident with the mark (24–25) on the gauge. The value of this indication of the waterline at moderate angles of heel is apparent, as simultaneously with an observation of the righting arms, there is provided a visual representation of the position of the deck edge relative to the waterline. To illustrate this, the case of a shade-deck vessel with openings between the upper and shade decks might be given. The vessel has a beam of 53 ft. and a freeboard of 5 ft. 9 in. The range of stability is 84 deg. and the maximum righting moment occurs at 45 deg. At 13 deg. the upper deck edge would be awash, and at 20 deg. the water would pass through the after openings in the side. This aspect of the condition of the ship is not observed in the ordinary curves of stability, but is readily suggested by the apparatus described.

The following note on the "Centre of Curvature of Flotation" is added *apropos* the remarks upon it in paragraphs 14 and 15. Figs. 7 to 10 show the loci of transverse meta-centres plotted on an abscissa of volumes of displacement, for four types of vessel. O_1, O_2, O_3, are the positions of the C.C.F. for three water-lines in each type spaced as specified. In the four cases the interval of separation between O_1 and O_3 is bracketed and figured up. Types I, III and IV would obviously admit of a fixed position being allocated to the C.C.F. over the range of draughts, or the equivalent, referred to in the text. Type II would require the adjustable arrangement of pivot described. If R and r be the actual heights of the C.C.F. with respect to a fixed datum line, for any two waterplanes representing the "arrival" and load draughts of a ship respectively, then by taking a fixed mean position for the C.C.F. the maximum error in draught at θ deg., where θ is of moderate amount, is given by—

$$\tfrac{1}{2}(R - r)(1 - \cos\theta)$$

which shows that considerable latitude in $(R - r)$ is permissible before incurring any appreciable error in draught at moderate angles of heel. In all cases the position of the C.C.F. at the various draughts can be easily determined, either by drawing the loci of transverse metacentres as shown in Figs. 7 to 10, or by a simple geometrical construction employing the ordinary meta-centric diagram.



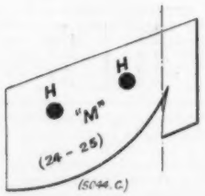


FIG. 2a.

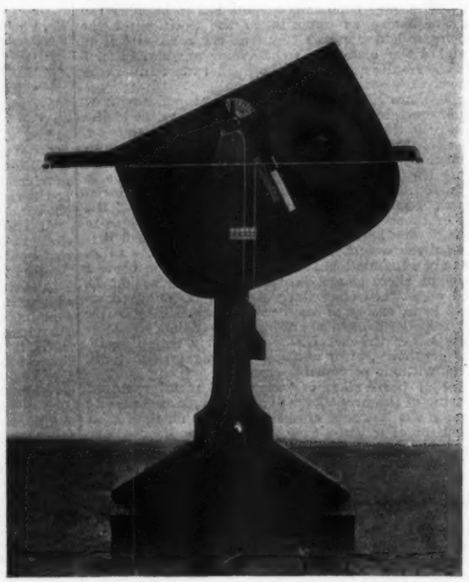


FIG. 6.

SOME EXPERIMENTS ON THE INFLUENCE OF RUNNING BALANCE OF PROPELLERS ON THE VIBRATION OF SHIPS.

(*For Description, see Page* 297.)

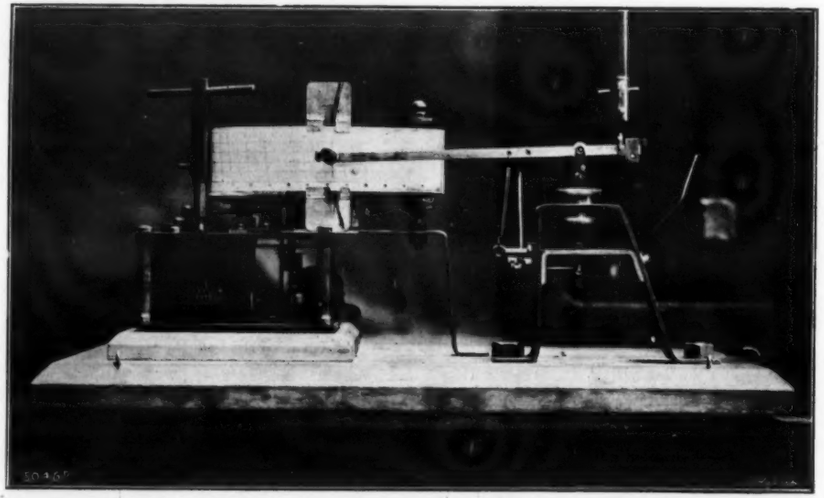


FIG. 6.

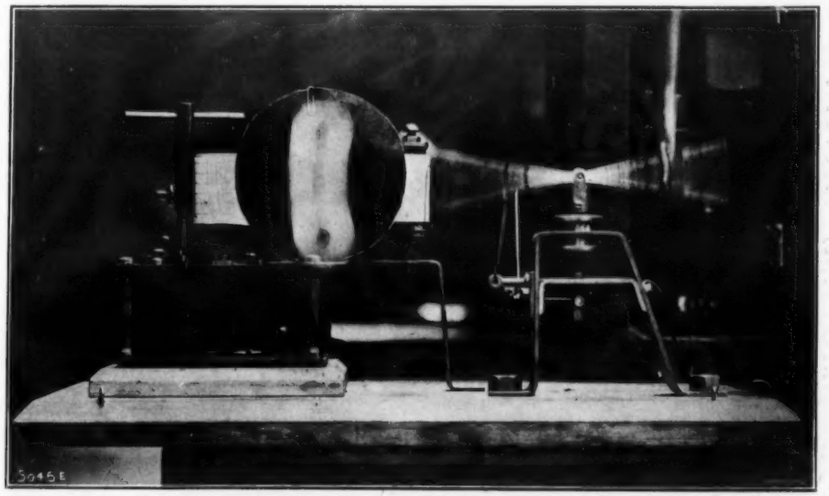


FIG. 8.

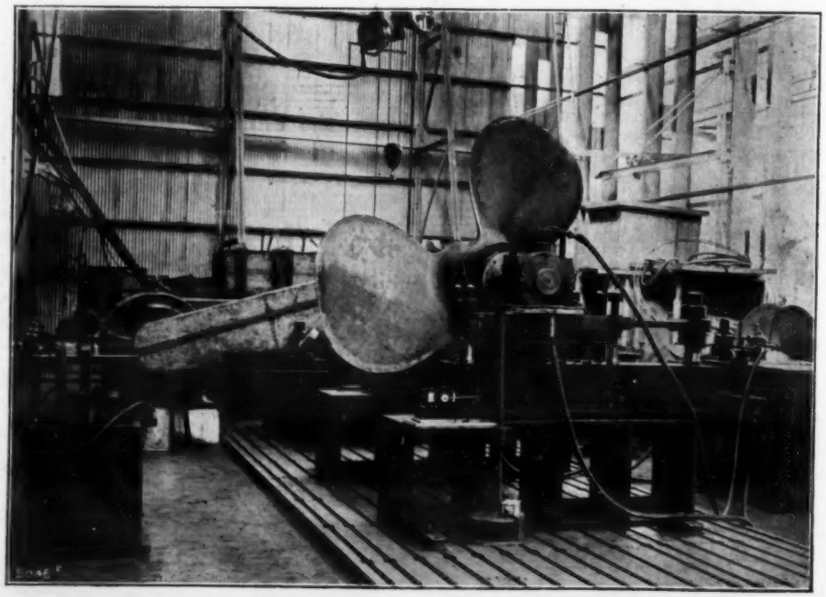


FIG. 7.

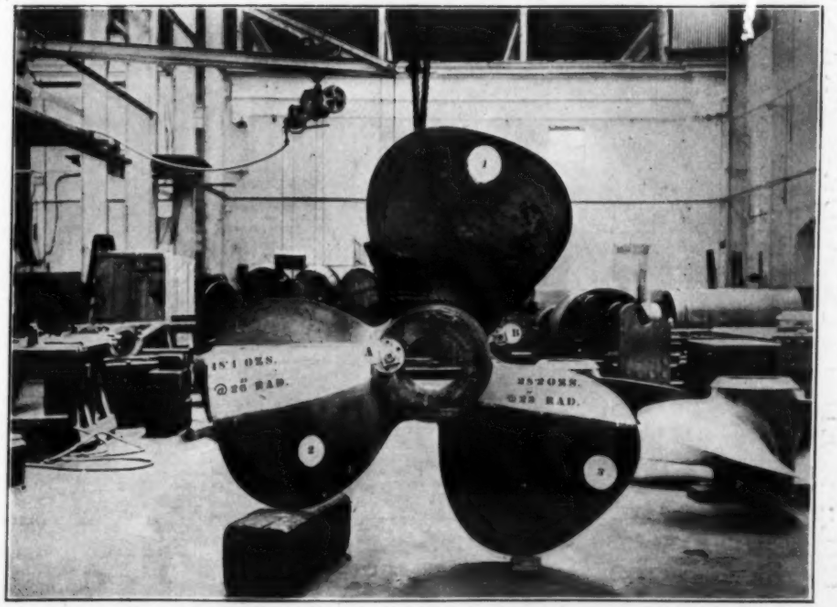


FIG. 9.

(*To face page* 298.)

OIL-FIRED (KERMODE'S PRESSURE-JET SYSTEM) NAVAL BOILER FOR THE NORWEGIAN GOVERNMENT.

(*For Description, see Page 293.*)

Fig. 1.

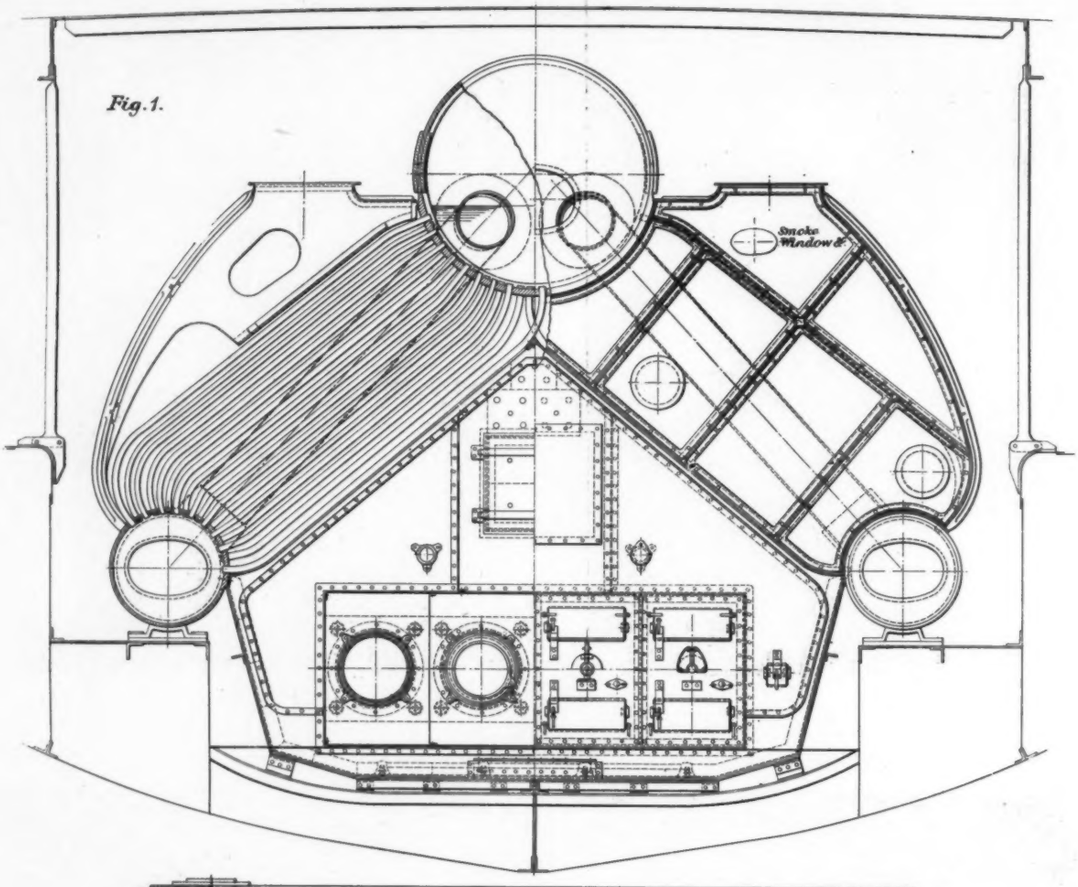
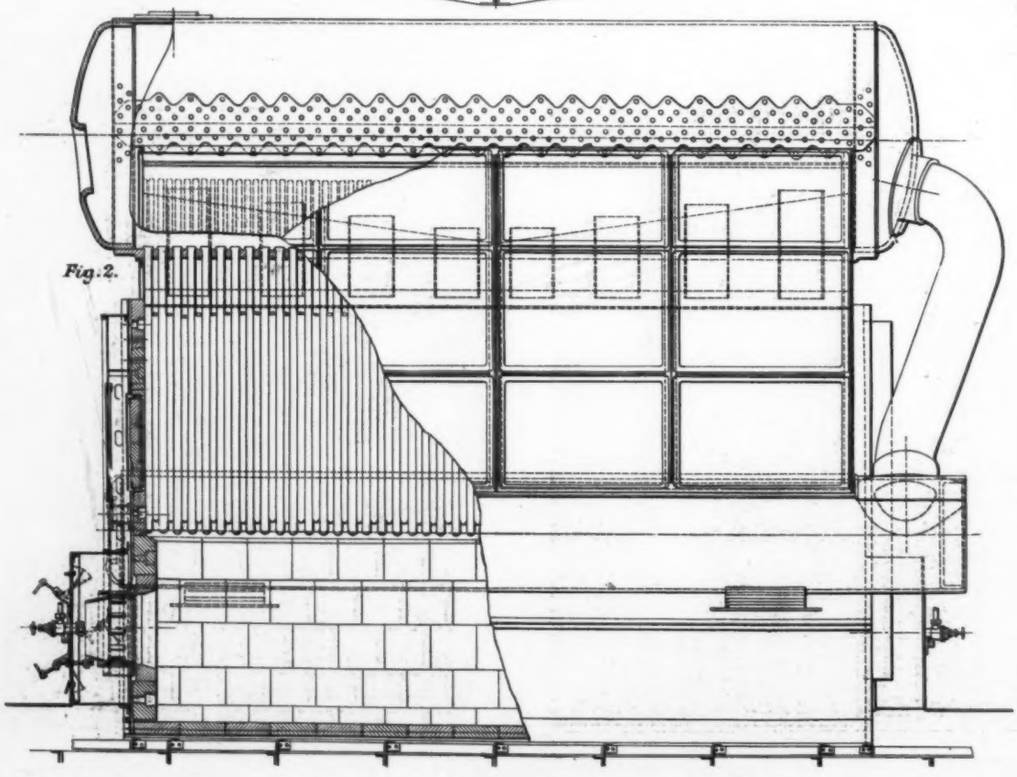
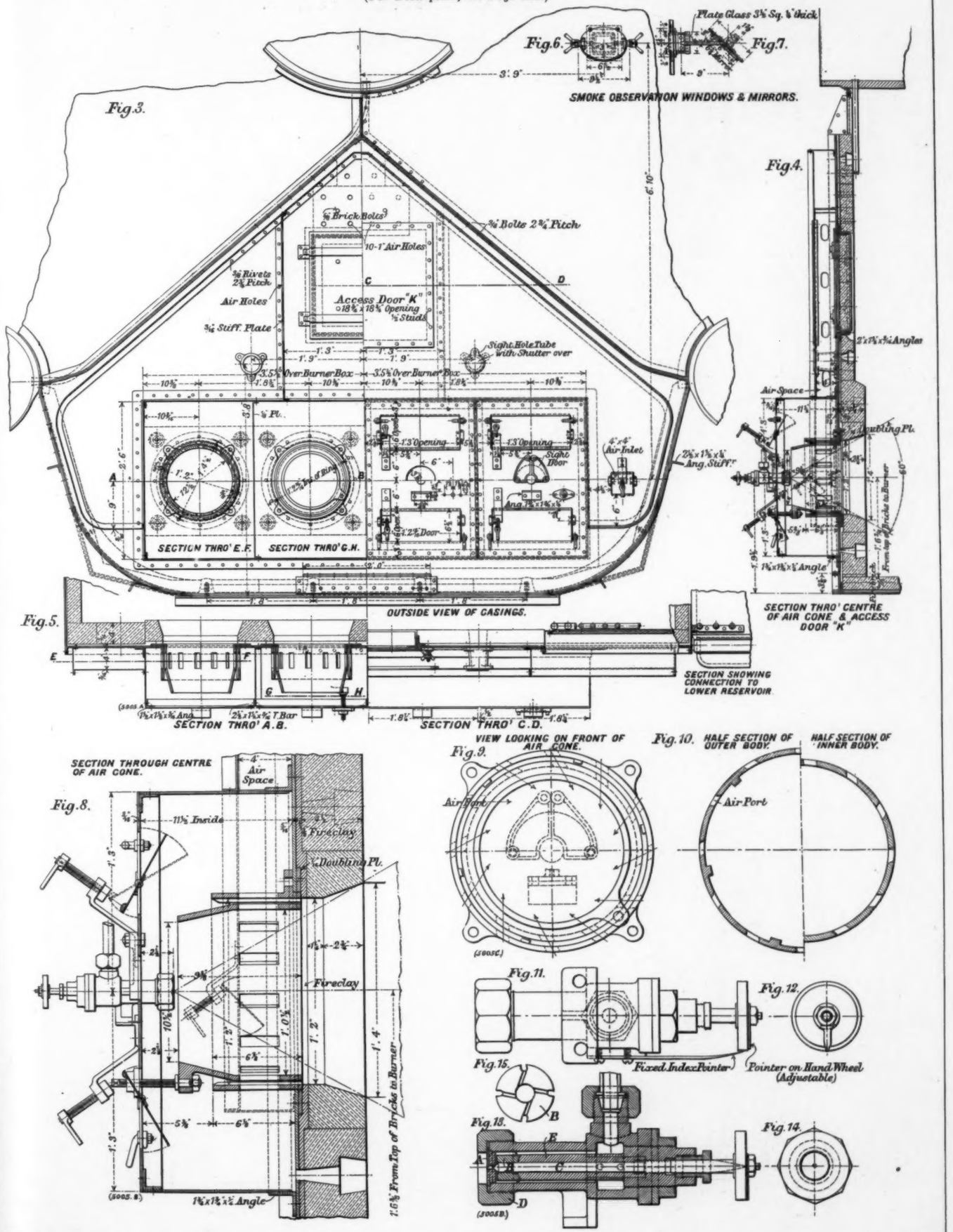


Fig. 2.



OIL-FIRED (KERMODE'S PRESSURE-JET SYSTEM) NAVAL BOILER FOR THE NORWEGIAN GOVERNMENT.

(For Description, see Page 293.)



APPARATUS FOR INTERPRETING STABILITY OF VESSELS FOR THE USE OF SHIPMASTERS.

(*For Description, see Page* 299.)

Fig. 1.

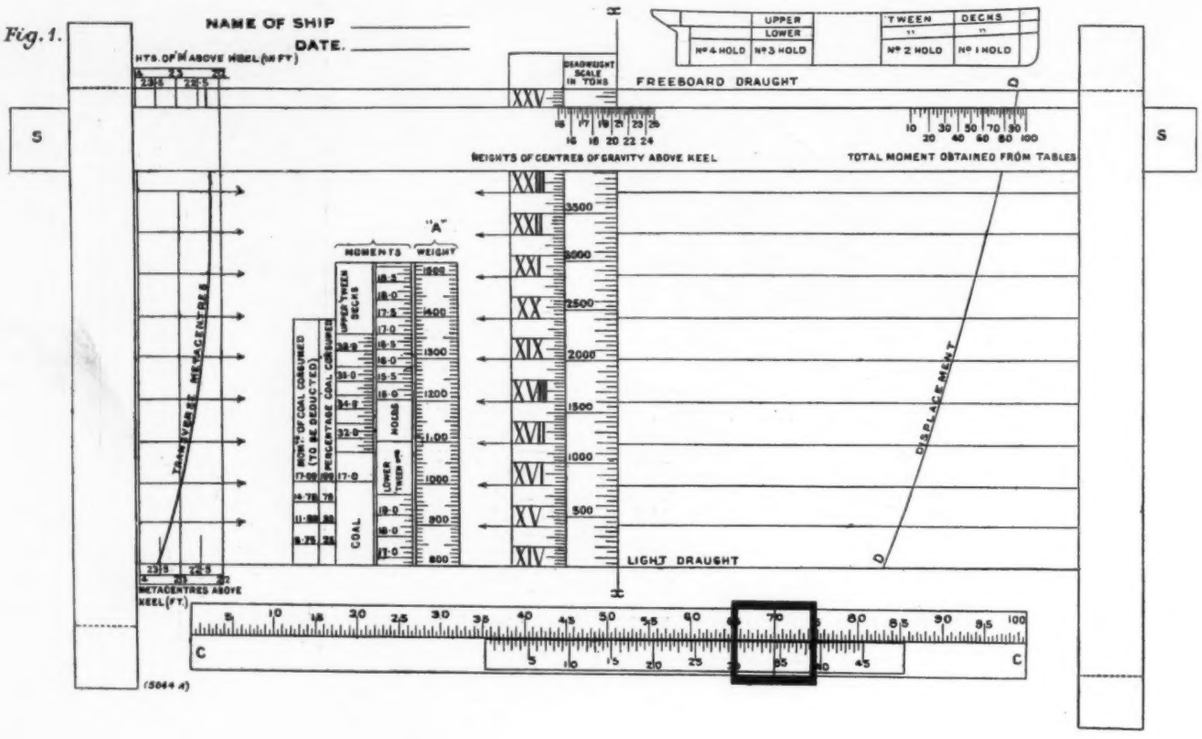


Fig. 2.

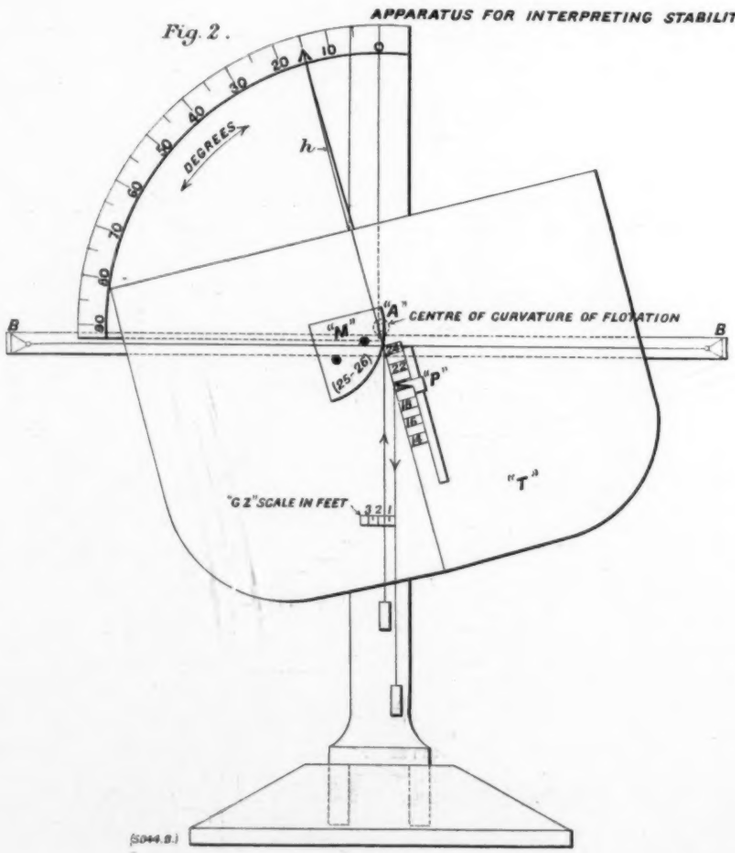


Fig. 5.

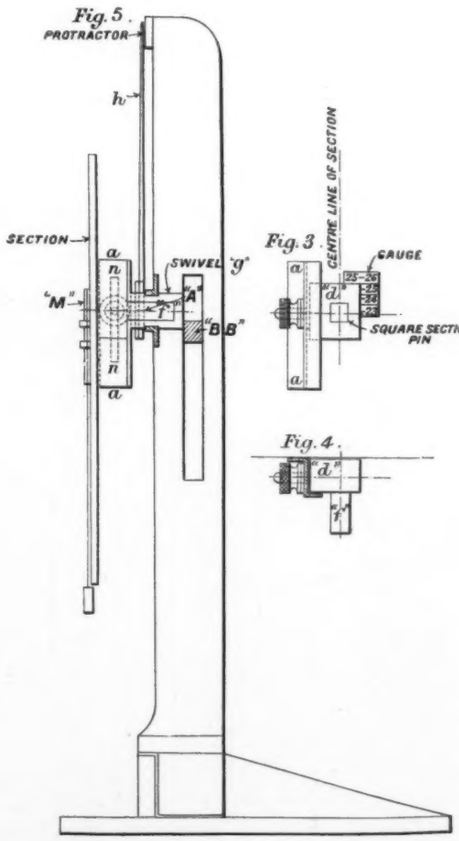


Fig. 3

Fig. 4.

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NOTICES OF MEETINGS.

THE SOCIETY OF ENGINEERS.—Monday, April 2, at 5.30 p.m., in the apartments of the Geological Society, Burlington House, Piccadilly, W. A paper entitled "Ball Bearings" will be read by Mr. A. Marshall Arter, F.S.E., A.M.Inst.C.E., M.I.A.E., Member of Council.

THE ROYAL INSTITUTION OF GREAT BRITAIN.—Monday, April 2, at 5 p.m. A general monthly meeting.

THE INSTITUTION OF CIVIL ENGINEERS.—Tuesday, April 3, at 5.30 p.m. Discussion on the following paper to be concluded:—"The New Electric Power-House at Birchills, Walsall," by Mr. Ernest Matthew Lacey, M.Inst.C.E. Papers to be submitted for discussion:—"The Coolgardie Water Supply, Western Australia," by Mr. Percy Vincent O'Brien, M.Inst.C.E., and Mr. John Parr, B.Sc., Assoc.M.Inst.C.E. "Water Supply in the Interior of Western Australia," by Mr. Percy Vincent O'Brien, M.Inst.C.E. And ballot for new members.

THE RÖNTGEN SOCIETY.—Tuesday, April 3, at 8.15 p.m., at the Cancer Hospital (Free), Fulham Road, S.W. Discussion on "The Future of the British X-Ray Industry," opened by Mr. Geoffrey Pearce.

THE INSTITUTION OF ELECTRICAL ENGINEERS: SCOTTISH LOCAL SECTION.—Tuesday, April 3, at 7.30 p.m., at the Rooms, 207, Bath Street, Glasgow. The annual report for the closing session will be submitted. Paper:—"Some Points in Connection with Engineering Specifications," by Mr. J. Shepherd, Member.

THE LIVERPOOL ENGINEERING SOCIETY.—Wednesday, April 4, at 8 p.m., at the Royal Institution, Colquitt Street, when a paper will be read by Mr. J. Hamilton Gibson, M.I.N.A., entitled "The Michell Thrust Block and Journal Bearing."

THE AERONAUTICAL SOCIETY OF GREAT BRITAIN.—Wednesday, April 4, at 8 p.m., at the Society of Arts. Mr. A. P. Young, of the British Thomson-Houston Company, will lecture on "Magneto-Electric Ignition on Aircraft." The chair will be taken by Colonel Sir Capel Holden, F.R.S., and the lecture will be illustrated by numerous slides.

NOTICE TO NON-SUBSCRIBERS.

In view of the restrictions now imposed by the Government on the importation of paper, and of the consequent shortage of supplies, readers who wish to be sure of obtaining "ENGINEERING" each week should place an order for the Journal with a newsagent or bookstall clerk. Owing to the scarcity of paper it will be impossible in future fully to provide for a chance demand for this Journal.

NOTICE.

Owing to the recent Government restrictions, and to the enormous increase in the price of paper occasioned thereby, the Proprietors of "ENGINEERING" are compelled to advance the price of this Journal from 6d. to 8d. per copy. This increase dated from and included the issue of Friday, March 16. The change will not apply to unexpired subscriptions.

ENGINEERING.

FRIDAY, MARCH 30, 1917.

THE METRIC SYSTEM.

AT the Institution of Civil Engineers last Tuesday Mr. Harry Allcock delivered the second lecture in the present series of discourses on economic subjects, the first of which we noticed in our issue of the 16th inst. The subject was "The Decimal System of Coinage, Weights and Measures." Engineers have no greater interest in systems of coinage than other business men, except as far as arises from the fact that they are usually more adept in the use of decimals. It was the portion of the lecture dealing with weights and measures that touched them most closely. Of course the decimal system the lecturer had in his mind was the metric system. There are only two systems possible in this country—our own and the system which is already obligatory with 437,000,000 people and optional with 727,000,000 in other countries. It is sheer waste of time to discuss novel systems based on the inch, or the link, or anything else. If we make a change we must adopt one that will be acceptable to our customers, and not one which will involve them in greater confusion than the present. This point does not yet seem to be clearly appreciated, judging by some of the remarks made in the discussion. Indeed, the discussion was extremely disappointing, the reason being that none of the speakers appeared to have had any practical experience of working with the metric system. Those who agreed with the lecturer did so mainly on economic grounds, while admitting that there were many difficulties, while those who disagreed enlarged on the difficulties and expense, but did so for general reasons, basing their prophecies rather on their fears than on their experience.

The meeting recalled a previous one, also held in the theatre of the Institution of Civil Engineers, but under the auspices of the Institution of Electrical Engineers, when Mr. James Swinburne was president in 1903. On that occasion Mr. Alexander Siemens was the protagonist for the metric system and Sir Frederick Bramwell for the British system, and both played their parts so admirably that they left nothing more to be said by those who came after. It is very doubtful if a single argument was adduced, for or against, last Tuesday, which had not been brought forward on the previous occasion. Yet in the 14 years which have elapsed a great amount of practical information respecting the working of the metric system has been gained here. Foreign customers have insisted in many cases of having machines made to metric measures, and manufacturers have accepted such orders rather than lose them. Locomotives, marine boilers, motor cars and aeroplanes have all been built under rigid inspection from drawings made in metrical countries, and there are scores of engineers who could have told the audience last Tuesday exactly how much extra trouble and expense were involved. One such speaker would have raised the debate on to a higher level, and would have enabled the audience to judge whether the proposed change was feasible in a commercial sense. Everyone admits that our dealings with many foreign countries would be facilitated if our units were such as our customers understand. The question is whether the expense and inconvenience of the change would be too costly. It is easy to declare that they would—or would not—be, but what is wanted is not airy opinions but actual facts. Such facts are available, and we trust they will be forthcoming to supplement the debate. As the discussion will not be reported in the Proceedings of the Institution, that avenue is closed, but our columns are open, and we shall be pleased to give publicity to any communications we may receive that will let light upon the question. There is ample material available, although it is mainly in private hands, but there can be no reason for withholding it at the present time. Whenever manufacturers have found themselves obliged to adopt the metric system they have done so; will they tell us what it has cost them in money and effort?

The adoption of the metric system in this country has been largely treated as an academic question in the past. In spite of our system—or want of system—we have been successful, and our exports have risen with satisfactory uniformity. We have made money, we have amassed capital, and we have spent lavishly. But we are now entering upon another phase under quite new conditions. After the proclamation of peace we shall be faced with greatly increased wages and enormous taxation, and the national income, which was once ample, will no longer suffice. Prices will be high, and although the working classes will be able to spend, the middle classes with fixed incomes will be obliged to curtail their outlay. Under such conditions we must extend our trade abroad by every possible means, and to do so we must copy our rivals—that is, we must take trouble to meet the desires of our customers. The first step towards that end is to count the cost and to compare it with the possible gain, and if the calculation shows a profit to go forward. It must be remembered that the cost is not a continuing one. Once the outlay and confusion attending the change have been encountered they are at an end, while the profit will go on from year to year.

We hear a great deal about supplying all the needs of the Empire, and no sensible man would shut his eyes to the importance of the subject. Our colonies have been more eager to meet us than we have to respond, and a speaker in the debate said that in Australia, from whence he came, they had been on the verge of adopting the metric system for some years, but that they had held back, awaiting the action of the Mother Country. But they were, he said, getting tired of waiting, and there existed a large party in favour of plunging at once. This disposes of the argument that we should disassociate ourselves from our colonies if we adopted the metric system. There is good reason to believe that they would all follow our example without delay.

There is now a Bill before Parliament for rendering the metric system compulsory; that is, all selling and buying would have to take place under metric

standards after a given time. It contains, however, a clause permitting manufacturing to be performed in any set of units, so that it would not create any difficulties in an engineer's shop except in nomenclature. Dimensions in catalogues and invoices would have to be given in metric units, and in some cases might be a little cumbrous, but that would be the extent of the inconvenience. It would seldom be necessary to go to a decimal part of a millimetre. Any British dimension can be expressed in millimetres with an error not exceeding one-fiftieth of an inch, and with an average error not exceeding one-hundredth of an inch. Of course, we talk glibly of thousandths, but when first our manufacturing engineers began to make shells it very soon became evident that very many of them were quite unable to work to anything like such a degree of accuracy. The experiment of making shells in one works and fuses in another revealed how little interchangeability was really understood. The war has taught us a great deal in relation to gauges and tolerances, but we are still short of perfection, and there are many works in which an error of one-hundredth of an inch is accepted with equanimity.

One of the speakers at the Institution objected strongly to any system being made compulsory. For the last few years the use of the metric system in buying and selling has been optional, but before that the British Imperial measures had been compulsory ever since their introduction, and no one had objected. It was as equally an offence to give the "long pull" as the short measure. But it is impossible to have two standards permanently in a country. Many goods are not made to order, but to stock, and they must then be available for any market. Whatever advantages either system may have would be entirely lost if both were in active operation at the same time. We have to make up our minds which is preferable, and then if its advantages will repay us for the cost of introducing it. This brings us back to our starting-point. Discussions like that of Tuesday night afford us no help in arriving at a definite decision. They are merely the reflex of the prepossessions or prejudices of a number of individuals. What we need is the considered opinion of men who have tried both systems, not because they liked complexity, or from mere love of change, but because their commercial interests seemed to demand the experiment. Since 1840 thirty-four countries have abandoned their original standards and have adopted the metric. Not one country has adopted the British measures, or any fancy or fresh standard, and no country has abandoned the metre and gone back to its old units. In no country was the change so difficult as it will be here, for in none was manufacture so highly organised. We shall have to pay our footing when we enter the community of metric countries, and the point that waits for settlement is what it will cost us. We hope that some of our readers will try and enlighten the engineering world. Our own impression is that the cost will be found to be very much less than many anticipate.

WOMEN'S WORK ON MUNITIONS.

THE exhibition of women's work at the Royal Colonial Institute, which was opened on the 26th inst. by Mr. Kellaway, M.P., will bring home to manufacturers, engineers, foremen and tradesmen the magnitude of the field now covered by female labour. The exhibits include parts for internal combustion engines; aeroplane engines of the rotary, vee and vertical types; magnetos, sparking plugs and accessories; aeroplane fittings and woodwork; tool-room work; guns and gun components; small arms and machine-gun parts; optical work; medical and surgical apparatus; welfare types of overalls, suits and clothing for special industries; light body armour and steel helmets; while those classes of munition work with which women labour is popularly associated—shot, shells, fuses, gaines, grenades and bombs—are also represented. The range of processes and occupations involved in the production of the parts shown is so wide that it may be said to cover all branches of the engineering trade—mechanical, electrical and chemical.

In the speech made by Mr. Kellaway the magnitude of the work done since the Ministry of Munitions was established in May, 1915, was shown by data of increase in output as follow:—18-pounder guns, 28 times; machine guns, 27 times; 4.5-in. field howitzers, 52 times; high explosives, 70 times; medium guns and howitzers, 71 times; and heavy howitzers above 6 in., 423 times.

The manner in which these results have been brought about is more striking when it is noted that of the men engaged in the trades concerned, at least 25 per cent. have joined the Army. In July, 1914, the women munition workers numbered 221,000; in January, 1917, their number had increased to 691,000, and even this figure is now probably greatly exceeded. The utilisation of this army of labour, however, would not have been possible, as Mr. Kellaway points out, had it not been for the co-operation of the employers as well as of the working men with whom these women had to work. The co-ordination of this work, effected by the dilution officers of the Ministry, also received graceful recognition.

The term "dilution" as applied to labour may be defined as the distribution of the skill of the individual over two or more pairs of hands. It frequently differs from the mere detailing of operations to the semi-skilled operator, the one-job machinist or fitter, as the case may be, which is rendered possible by a largely increased output. Dilution, in its fullest sense, implies the utilisation of the efforts of all the individuals concerned in such manner as to obtain the maximum from skilled labour. This implies, further, that the scrap made must be low in percentage, otherwise waste of skilled labour in the particular instance or in previous operations will result. The necessity for the principle is due to the shortage of fully-skilled labour which exists in many munition works. The advent of women labour in the machine shop was considered by many employers, managers and foremen as a step which would affect only the capstan lathe, the drilling machine and the milling machine fitted with fool-proof jigs. Repetition was their watchword, and it was considered to be absolutely essential for the successful employment of women; such work as shells and fuses, in which repetition was indefinitely great and measurable only by the duration of the war, was taken by many to represent the limit of the useful application of female energy. The task of the technical section of the Ministry has been, and is still, to combat this attitude and to educate and assist employers, managers and others by reference to the best practice in dilution as exemplified in other munition factories. This work has been carried on by visits of dilution officers, distribution of process sheets, loan of photographs, visits to other firms by special arrangement, and by exhibitions, of which the present one is the first, in which photographs of the machines and work are supplemented by the parts themselves, so that the actual piece and its finish can be examined critically.

Mr. Kellaway quotes that "a prominent engineer has expressed his firm conviction that, given two more years of war, he would undertake to build a battleship from keel to aerial in all its complex detail entirely by women labour." Those who see the work at the present exhibition and realise that it is only a minute fraction of what could be brought together by the technical section of the Ministry, had they the space requisite, will perhaps appreciate that the idea is neither fantastic nor a vision of Jules Verne or H. G. Wells. The woman who has trained for the trapeze can find her vocation at the giddy heights of a Scotch crane, and the girl who is proficient at dancing is well equipped for undertaking work involving movement of position. The Ministry has found cases where these specialised abilities have been successfully applied to industry. Only a small modification of the gear of the heavy forging press or of the appliances in the moulding shop would be necessary to decrease the muscular effort required by one-half and to increase the distance of the operator from the hot metal or furnace by the equivalent. There are, in fact, some operations in the smiths' and press shops in which the aptitude of women for correct appreciation of time intervals shows to great advantage. The motion study has been a favourite subject with American factory organisation experts for several years, and the sequence of movements made by the operator is a theme which would bear careful investigation. This sense and its influence on industrial processes was alluded to by Jules Verne some thirty years ago in "The Begum's Fortune"; to-day, by the aid of the cinematograph, it can be investigated on a scientific basis. It is to be hoped that any further exhibition held under the auspices of the Ministry may be undertaken on a larger scale and supplemented by a series of films illustrating good examples of motion study; films which the photographic section of the Ministry should know best where and how to obtain.

In the training of the army of women labour the part of the employer, the intermediary and workman has been recognised; it is, however, equally necessary to consider the effort of the individual women workers, for the results obtained from their labour and the shortness of the time in which they arrive at proficiency have exceeded all expectation. This can be explained by various causes; some special to war conditions, such as patriotism, the personal factor involved by relations or others at the front, or the need of the pecuniary reward; or others special to the natural aptitude of a large majority of women for manual work, and last, but not least, the special efforts made to train women labour by efficient methods.

The ordinary apprentice *learns* to file flat in the course of years of more or less close personal application. Many a woman worker can be *taught* to file as flat in less than one-tenth of the time, provided she is instructed by a really capable and painstaking demonstrator.

Much is already known as to the methods of selection of labour, and some instances which appear quite anomalous have been investigated, for example, the selection of operators for rifle-barrel straightening is primarily by the colour of the eyes, grey or blue having been found to provide the highest percentage of efficient workers.

If we may criticise the present exhibition at all, it is that, in any future demonstration of the kind, attention should be devoted to the instruction of employers and managers in the best methods of training their women labour. For some classes of work preliminary training in a training school, with gradually increasing hours of work, so that the times worked at the end of the period of training are the same as at the actual factory, is found to give good results; for other classes of work it is preferred that the worker should commence in the actual works under the prevailing factory conditions. Much depends on the preliminary training being of the proper kind and on the subsequent conditions. It is established by experience that women workers produce more work if they do not work more than three consecutive hours without a break of 10 to 15 minutes; it is essential for efficiency that the welfare conditions should be good; and if there is to be a serious attempt to do work involving setting tools and setting up machines, reading of blue prints, and taking greater responsibility, such increased responsibility should in all cases carry proper recognition and promotion.

THE INSTITUTION OF NAVAL ARCHITECTS.

THE fifty-eighth session of the Institution of Naval Architects opened on Wednesday last in the Hall of the Royal Society of Arts, Adelphi, London. In the unavoidable absence of the president, the Right Hon. the Earl of Durham, K.G., the past-president, the Marquis of Bristol, occupied the chair. The attendance was large, especially in view of the demands on the members of the Institution in connection with the supply of war material.

The secretary, Mr. R. W. Dana, read the annual report of the council for 1916. Having referred to the difficulty in carrying out a full programme for the spring meeting, owing to the war, the report stated that the membership had suffered rather heavily from losses due to deaths and resignations. The total number of all classes elected during the year was 127, including 30 transferences from one class to another, but on a balance there was a slight decrease, the total membership being 2,065, as compared with 2,092 a year ago and 2,175 two

years ago. The finances continue to be satisfactory. Regret was expressed at the loss of several distinguished members. The following members had been appointed to serve on the Advisory Committee on Mercantile Shipping: Mr. G. J. Carter (chairman), Mr. W. S. Abell, M.Eng., Mr. Summers Hunter (resigned), Mr. James Marr, Mr. A. C. Ross, Mr. W. Ronan Thomson. The council had nominated the following representatives of the Institution: On the Engineering Committee of the Advisory Board for Scientific and Industrial Research, Sir Archibald Denny, Bart., and on the Shipwiring Rules Committee of the Institution of Electrical Engineers, Mr. A. W. Stewart. The Elgar Scholarship had been awarded to Mr. R. J. Shepherd, of H.M. Dockyard, Devonport, who is now following the course in naval architecture at the Royal Naval College, Greenwich.

The report of the scrutineers was next read, and showed that Mr. James Bain, late superintending engineer of the Cunard Steamship Company, had been elected a vice-president to fill the vacancy caused by the death of Sir Theodore Doxford. The following were elected members of council: Professor T. B. Abell, Messrs. W. S. Abell, M.Eng. (chief surveyor to Lloyd's Register), C. E. Allan (Belfast), G. J. Carter, H. R. Champness, M.V.O., A. Cleghorn, James McKechnie, Sir James B. Marshall, K.C.B., Messrs. J. R. Perrett, Professor J. J. Welch, M.Sc., and Engineer-Commander W. M. Wisnom, R.N. (ret.); while Admiral Sir Reginald Custance, G.C.B., Sir J. Alfred Ewing, K.C.B., and Sir Thomas Sutherland, G.C.M.G., were elected as associate members of council.

The chairman presented the annual gold medal of the Institution to Professor T. B. Abell, M.Eng., for his paper on "Experiments to Determine the Resistance of Bilge Keels to Rolling," and the premium to Mr. A. T. Wall, for his paper on "Some Effects of the Bulkhead Committee's Report in Practice."

The Inaugural Address.

Lord Bristol then read the following communication from the First Sea Lord, Admiral Sir John Jellicoe:—

"In the public interest, and for obvious reasons, certain restrictions have been imposed on the Institution of Naval Architects during the war, and these have necessarily detracted somewhat from the interest which is generally attached to these meetings. It is scarcely necessary for me to say how much the Navy owes to the shipbuilding and engineering professions and to all the industries connected with those professions; but I should like to bear tribute to the patriotic action which the members of the Institution have shown in giving their services freely for the common good." All, Lord Bristol remarked, would be proud of this message from one who had done so much for the country.

Continuing, Lord Bristol said that, in these days, when the whole nation should be mobilised for national service, it particularly behoved the leading men in every county to set an example to their fellows by aiding with their presence and experience the various local committees and tribunals which had been set up to assist the Government in the herculean task placed on their shoulders by the war. Lord Durham had been no laggard in this respect, and it was to be hoped that the urgent public affairs which prevented his attendance, while a loss to the Institution, would be a gain elsewhere. Lord Bristol refrained for obvious reasons from commenting upon the output of ships, and there were only a few points to which he proposed to allude. He referred to the honours which His Majesty had conferred upon the Members of Council of the Institution, but as we have already dealt with that matter,* we need not repeat the names here. At the outset of the war the council offered the services of the Institution to the Government, and many individual members had followed suit; and the council was fortunate in possessing, and the country in obtaining, the advantage of the technical knowledge and organisation thus available. The activities of the Institution had been much restricted by the war, its labours in the national interest being chiefly represented by the work of individual members connected with the shipbuilding and marine engineering firms of the country. Members had also acted on the various committees organised to deal with the problems of supply created by the war, and when the history of the war came to be written, he felt that the part played by shipbuilders would be a source of pride to the Institution.

The work of engineers, in its broadest sense, was not always recognised as it deserved. But the council had been considering for some time how best to draw into closer touch the various institutions representing engineering professions. Some form of permanent council might be set up for co-ordinating the common interests. Such a council would not be endowed with power over the affairs of any of the constituent institutions, but in making its recommendations it would have the weight of the whole profession behind it. He would not personally recommend such a council if he thought that there would be any attempt to aim at the worst features of modern trade unionism, namely, the limitation of the daily production of an individual, a principle which had done so much to hamper our rulers in the organisation of the resources of the country against the common enemy. He could safely predict that such a principle would form no part of the suggested scheme. The matter had not reached the stage at which the council could report upon it, but he was violating no confidence when he stated that the movement had been supported. He hoped the result would prove a real benefit, not only to the Institution, by increasing its prestige, but to the engineering profession as a whole, in enabling engineers to render greater service to their country and in raising the standard of professional qualification. The speaker then introduced a message he had received from Lord Durham, in which, after expressing regret at being prevented by other public duties from taking the chair at the annual meeting, he referred to this subject. He said that he "had also hoped to say a few words about the establishment of an engineering senate, which has been so ably, and, in my opinion, so conclusively advocated by Professor Dalby. I should like to emphasise the fact that the influence of engineers in the work of the Empire is not what it ought to be. Governments are less durable than institutions, and it is not a matter of *amour-propre*, but a desire for co-ordination of action and continuity of practice that has prompted this suggestion. I am not overstating the case when I say that institutions representing engineering contain all the most eminent and intellectually powerful men in the profession, and they are of national importance in discovering and encouraging rising talent. Surely there ought to be a permanent council representing the considered judgments of such men and to give expression to their views. A permanent council or senate would increase the usefulness of our Institution, and would add strength to the State."

Lord Bristol, continuing, said that, however important such questions might be to the professional interests involved, it was to the greater issues of the war that men's minds were directed to-day. Our armies and those of our Allies were now reconquering territories long held by the enemy, who were now turning an anxious face towards their own frontiers. The Navy's vigilance had guarded these shores satisfactorily, at least from all above-water enemies. The difficulties they had had to contend with had been increased a hundredfold by the inhuman style of submarine warfare which the Germans had adopted, which, as a method of commerce destruction was new to civilised naval warfare. We could not afford to pass lightly over the inroads thus made into our mercantile tonnage; it was necessary not only to find a cure for the disease, but, while this was being sought, to take immediate steps for the provision of additional tonnage and the creation of food and other supplies, and save the country from possible panic and want. Meanwhile, such steps were being taken in the direction of arming merchant tonnage, so that ships might defend themselves legitimately against capture and be provided with a means of attack which should give at least partial security. It had been shown that the number of armed vessels sunk was small compared with the loss of unarmed ships, while the arming policy had now received the *imprimatur* of the United States of America. Among quickly improvised means, these appeared to the speaker to be the most legitimate for the security of merchant ships. Such means did not secure immunity from attack, but the attacker would be more chary of approaching his prey, and his chances of sinking a vessel with one torpedo would be reduced; the more torpedoes the enemy could be made to use, the more the power against us would be discounted and the smaller would become the radius of destruction. For the attainment of the ends in view it was necessary to look to those who had under control the management of our shipping. Lord Bristol stated that the council of the Institution had appointed a committee, under the presidency of Mr. S. W. Barnaby, to consider the question of the effect of mine and torpedo explosions on the structure of merchant ships. The subject no doubt, formed part of the larger question within the jurisdiction of the Controller of Shipping, but the speaker hoped that some useful measures, whether temporary or permanent, would result from the investigations made. Measures had been taken for increasing merchant tonnage, and the impending participation of the United States of America in the war would possibly free additional tonnage for immediate use in relief of the world's depleted stock of ships. Nevertheless the outlook was a serious one, and the First Lord of the Admiralty had rightly drawn attention to the gravity of the situation. The speaker concluded by saying that so long as the Navy remained true to the great traditions of the past, and so long as the merchant service, by its splendid heroism in facing the dangers of the situation, also upheld its great tradition, we might look to hold our own in that element which we might well claim as the birthright of our race.

At the conclusion of the president's address Colonel Lorenti, the official representative of the Italian Society of Naval Architects, bore greetings to the British Institution, and expressed the hope that there would in the future be increased interchange between the two countries, both intellectually and materially.

Lord Brassey, who also spoke, said that the submarine was the great anxiety of the day. We had to admit that no patent had yet been discovered for completely and absolutely ensuring our shipping against the risks arising from the improper use of this weapon. We did know, however, that the two most effective methods of meeting the danger were embodied in the torpedo-boat destroyer and in arming our merchant vessels. This latter plan was commended by actual experience in the most remarkable way. He might instance the adventure during the last few days of a boat belonging to a small line of colliers trading between Cardiff and Rouen. The boat in question was armed with a three-pounder merely, and was not provided with a special skilled gun crew, having to rely entirely on naval reserve men. Nevertheless the collier, weakly armed as it was, fought a submarine for 1½ hours, driving her off and getting safely to Rouen. He questioned whether as much as possible was being done in this direction. His own feeling was that no ship should be allowed to put to sea unless suitably armed. As matters stood, at one French port he had watched cargo boats steaming to and fro for hours, waiting for the opportunity to enter. This state of affairs constituted a direct temptation to the enemy; and, in fact, in the course of the afternoon one was sunk, though the submarine was subsequently destroyed by a French torpedo-boat destroyer. He doubted whether we were building as many of these destroyers as was desirable. Some of our great dockyards, at any rate, were being reserved for emergency purposes, such as the repairs after a possible action at sea, and he rather thought it would be better to make less provision for this chance and do more in the way of new construction.

Standard Ships.

Mr. D. B. Morison next read a paper on "Standardisation as Applied to the Machinery for Cargo Boats." This paper is reprinted on page 294 of this issue. Some additional remarks were made by the author at the conclusion of his paper. He said that the guiding specification of the

* See page 158, *ante*.

North-East Coast Institution of Engineers and Shipbuilders* was the result of over three months' study by a committee of experts, and he might add it was now being submitted to the criticism of shipbuilders and shipowners. It was a finished article representing the average of the best practice of the district. It had been the intention to refer to it as the guiding specification of the society responsible for it, but in view of the president's remarks he hoped that it might be possible to make it a national specification approved by the Institution of Naval Architects and by the local societies in England and Scotland. The specification might be taken as representative of an up-to-date triple-expansion marine engine. It was offered for the use of builders at a small fee, and these fees were to be applied to research on a more extended scale than had hitherto been practicable. Thus if a man had more brains than money and brought a new idea before the council, his scheme would be considered, and, if approved, funds would be found not merely for patenting it, but for determining its value in actual practice. He thought this arrangement marked a great step in advance, but a necessary one, since in his opinion wider views must prevail amongst manufacturers than had hitherto been the case.

The discussion was opened by Lord D'Abernon, who expressed his general agreement with Mr. Morison's views on industry and economics. Although the speaker had arrived at his own opinion by a different path and from different data, one of the most striking results of the present industrial problem was the conclusion arrived at, by those most competent to judge, that the old individual competitive system, in spite of many advantages which he fully realised, was in some respects wasteful. As chairman of the Central Board for the Control of the Liquor Traffic he had ascertained that with a different organisation a larger profit could have been derived from the same total trade, or, conversely, an equal profit from a smaller trade. The same remark applied to railways and coal mining, and could apparently, from Mr. Morison's paper, be also extended to marine engine building. He would like, however, to substitute for Mr. Morison's maxim that high pay was necessary for maximum production a slightly different one, viz., that maximum production depended upon good conditions for the workmen, both inside and outside the factory. An increase of the sum paid over to the workmen each week was not the only, or, indeed, the best, method of ensuring the desired intensity of application. No one who brought a fresh mind to the study of past trade disputes could fail to be disappointed by the fact that the large increases effected in wages had been effective neither in removing the discontent nor in leading to the abandonment of the consistent restriction of output. Some had accordingly come to the conclusion that better results would accrue were more done to see that work was done in better conditions in the shops and better provision made for recreation outside. He himself believed that the historian of the future would look back to the expenditure now being made to these ends as the best spent money of the century. Many of his hearers were, he knew, pioneers in this matter, and the speaker claimed that the Government had been fair and far-sighted in allowing expenditure on canteens and the like to rank as a working expense before estimating excess profit duties. The chance should be seized now, however, as the Treasury was not likely to maintain this far-sighted attitude after the war. With most of what Mr. Morison had said on the question of standardisation the speaker was in agreement, but he thought his definition of standardisation open to criticism. "To determine the best and make the best" had nothing to do with standardisation. The whole principle of standardisation implied sacrifice, individual requirements being modified to suit the general, with a compensating gain in lower costs. In one other point he differed from the author, who seemed to imply that to effect an improvement it was merely necessary to appoint a committee. The speaker's own experience was that committees were rarely progressive, seldom bold, and always suspicious of novelty. In itself, he thought that standardisation rather tended to relax the pursuit of improvement, and hence some progressive force would be required to counteract this. To get high productivity standardisation was necessary, but it was correspondingly anti-progressive and must be supplemented by something which would encourage variety. He doubted if a committee would be effective in this regard. Sir J. H. Biles had submitted a memorial to the Dominions Royal Commission, showing how the whole question of sea transport was largely governed by harbour accommodation. On a given route a shallow and inadequate harbour injured every other port on the route. Hence the proper development of a port was not of merely local importance, so that standardisation here would be standardisation in the best sense. He believed that the Institution of Naval Architects could render a great service to the Empire by advocating harbour development along this line. Economical, rapid and easy transport was essential to the maximum development of our resources, high transport costs having proved great obstacles in the past.

Mr. J. Milton said that the author had quite rightly stated that the rules and regulations of the Board of Trade, Lloyd's and other corporations were based in part on physical facts and in part on individual opinion. The latter would, however, still play its part if standardisation became general, but would be the individual opinion of a committee. He regretted the addendum the author had made to his paper, which was misleading. The speaker was not responsible for the Controller's standards, though he was consulted in the matter. The essentials were to get the work done quickly and the engines to work. Some peculiarities of the specification were due to the difficulty of getting certain materials, so that others had to be substituted. He quite agreed with the author that the registering societies should adopt a single standard for structural strengths. This had been a serious problem in the past. A boat built here to Lloyd's requirements, with boilers working at 180 lb. per square inch, might, on being transferred to some colony or dominion, be required to lower the pressure to 160 lb. per square inch. An engine built to work with the higher pressure would be relatively worse with the lower, and the boat suffered accordingly for the whole of its working life. He might add that during the 27 years he had been at Lloyd's not one case had occurred of a boiler built to Lloyd's rules proving inadequate to its work, and at present more than half the marine boilers built were constructed to Lloyd's rules. Standardisation in this matter would therefore be highly advantageous, and the present time was especially favourable to united action in this matter by the Board of Trade and the registration societies. He suggested that the Institution should take the lead in forming a committee to this end. Such a committee should comprise, in addition to representatives of these societies and the Board of Trade, such men as the superintending engineers to great steamship lines.

Mr. J. H. Gibson, who followed, said that before the days of the steam turbine a certain firm, not a hundred miles away from London, appeared to its competitors to obtain more than its fair share of Government work. The reason was that this firm had evolved its own standard engine, designed to reduce to a minimum the number of working parts. Thus the eccentric rod and top strap were in one, the quadrant bar was single in place of double, and no attempt was made to bring the eccentric rod and valve spindle into line. The air pump was driven direct from the low-pressure crosshead without use of levers. How this engine came to be accepted was a mystery. It was commonly reported, however, that the builders refused to depart in any way from their standard, stating that the only function of an engine was to maintain a propeller in motion at so many turns per minute. There was a good deal to be said for this attitude. Mr. Morison ranked thermal efficiency as more important than mechanical. He thought most sea-going engineers, however, would give primacy to the mechanical side of the problem. Once the main proportions were settled little could be done to increase thermal efficiencies. Ample boiler power should be provided. He knew of one case where a superintending engineer insisted on four boilers being put in, though the builders thought three ample, and in the naval service, where good coal and good firemen could be relied on, one boiler would have sufficed. Yet the superintendent engineer, knowing the conditions of service with poor coal and native firemen, was quite right in insisting on the extra boilers.

Ordinarily the sea-going engineer cared little for economisers and the like. If wise he looked after the air-tightness of the glands and worked at a vacuum which would give him a fat low-pressure card and a hot feed, which he would push into the boiler as directly as possible. He was glad to note that the North-East Coast specification dealt with general requirements only. He had compared it with the Government standard and found little difference in essentials. The cut-off was earlier, leading to greater economy, but, on the other hand, the standard engine had larger exhaust ways, and its later cut-off tended to steadier running. He thought that the term standardisation was liable to be abused. It might be taken to mean interchangeability, thus reducing engineering to mere manufacturing, which would, he thought, be welcomed by Mr. Morison as little as by himself, though of course small components should be interchangeable, and limit gauges were valuable for bolts and spindles up to 5 in. or 6 in. in diameter. In present conditions fuel economy was of secondary importance.

Mr. G. J. Carter, who followed, said that in forming the advisory committee in association with the Shipping Controller which had drawn up the specification for standard ships we had for the first time on record an instance of a Government Department calling in the aid of independent engineering and shipbuilding experts. He thought it was the duty of the Institution to support this new departure. He knew that the Shipping Controller and his committee would be glad of any further expert assistance they could obtain.

Mr. Bremner said that the primary consideration in labour economics was a high productive capacity for each labour unit paid for. No one could dispute that the most potent incentive to this was personal gain, and the more direct and immediate this was the better. Undoubtedly the productivity of labour in the time immediately before the war had fallen ruinously low, and it was of primary importance that relapse should not be experienced after the war. He considered that in the future more stress should be laid on payment by results. The whole responsibility for future productivity did not, however, rest on labour, and very high organising capacity would have to be shown by the management, and to this organisation the establishment of definite standards would constitute an important contribution.

In reply Mr. Morison said that he had not intended in his supplemental remarks to do more than rouse sympathy for the idea of greater co-operation. If the present opportunity were missed nothing could be done for three years, as most yards were booked up for two or three years ahead. It would be a thousand pities if the chance for co-operation on the broad lines he had indicated was not taken advantage of. Already certain firms had expressed their readiness to accept the "guiding" specification, and the fees for it would be at once available for encouraging further developments of the industry. As for Lord D'Abernon's remarks on standardisation, the speaker thought that there were two types of standardisation, the one leading to continuous improvements and the other to stagnation. If all the talents of the various technical institutions were concentrated on the progressive improvement of the standard specification it would, he thought, prove of immense value. The progressive force for which Lord D'Abernon called would, he thought, be provided by the intense competition which would be experienced two or three years after the end of the war. Mr. Gibson had called attention to the ample bearing surfaces provided in the Shipping Controller's standard specification, and he would admit that this specification was excellent, and by increasing scantlings in certain cases by $\frac{1}{8}$ in. to $\frac{1}{4}$ in. the design would be

* See page 127 *ante*.

brought into harmony with the guiding specification issued by the North-East Coast Institution, and this would, he claimed, be highly advantageous. In placing thermal before mechanical efficiency he had followed the law of nature.

METHOD OF OBTAINING FOR SHIP DESIGN THE SPACING OF BULKHEADS ACCORDING TO THE RULES OF THE INTERNATIONAL CONVENTION.

The first paper taken at the afternoon meeting on Wednesday was the one having the above title; it was read in abstract by the author, Mr. W. J. Lovett. It dealt with floodable length curves, freeboard ratio correction, block coefficient correction, sheer ratio correction, variation of form correction, permeabilities and factor of subdivision. In applying the curves, the author stated that the method which had been found most convenient in practice was illustrated in a table contained in the paper, which gave the floodable lengths as percentages of the ships' lengths and also the permissible lengths of holds in feet for three assumed vessels of varying particulars. An examination of the table showed how readily the approximate spacing of bulkheads could be obtained by the application of the method proposed by the author. The latter also pointed out the results of the fitting of a cruiser stern to merchant vessels.

Professor J. J. Welch, who opened the discussion, stated that the author's paper followed upon a similar paper which had been read at the spring meeting last year by Mr. A. T. Wall, and he was quite sure that it was of distinct value to designers of ships. Mr. Lovett's curves would be of great assistance to them for arriving at the curves of floodable lengths for any permeability. The author had made experiments on the question of permeability and had found the matter a difficult one; that was what he (Professor Welch) would have expected. It was shown clearly in the Bulkhead Committee's Report that a 60 per cent. permeability was taken as a fair average; as for the author's suggestion that when the figure was over 60 per cent. the boat should be allowed to go on a deeper draught, he (Professor Welch) doubted whether the deeper draught was a practical proposition. The author had pointed out the variations brought about by alterations in the block coefficient and sheer ratio, and he had said, in regard to the block coefficient, that there was an increase in floodable length for both an increase and a reduction of block coefficient. It seemed to Professor Welch that this was roughly analogous to what one found in the case of resistance of vessels. At a certain prismatic coefficient, if there were an increase or a decrease of that coefficient, one had an increase of resistance. The curves given were all valuable; perhaps the least valuable part of the paper was that which dealt with the influence of form. Referring to the curves, it would be found that the variations in the percentage for the variations in the shapes were relatively small. For extreme types varying largely from the standard form the matter was different. His (the speaker's) opinion was that it was best to adopt the Bulkhead Committee's Report for change of form when a distinct change of form was involved. The type of information supplied in the author's paper was exactly what the Bulkhead Committee had hoped would be forthcoming. The author had pointed out that the cruiser stern was, to some extent, unduly handicapped by taking the length at the water-line; his example, however, did not show an undue handicap.

Sir William E. Smith, who followed, said he had not been on the Bulkhead Committee, as the former speaker had been. Permeability, as had been stated, was a very difficult question. One could not expect two cargoes to be of the same permeability; moreover, one cargo varied in the course of a voyage, at any rate in the vertical distribution of permeability. Many experiments had been made in this respect with different sorts of coal, also patent fuel, and on the solid matter contained in a cargo; tables had also been drawn up on permeability and sinkage. He noticed that the author had not mentioned stability.

Mr. A. T. Wall congratulated the author on his contribution; he had spent a large amount of time upon it and had given the various points dealt with a thorough test. The method he had put forward was a simple one to put in use, and it would considerably facilitate the work of designers. Mr. Wall, referring to the curves for floodable length, said the corrections could be simplified. He (the speaker) found the author's figures for variation of form correction to be low, adding that the average variation showed the increase in floodable length to be more near 6 per cent., whilst the author's figure was 2 or 3 per cent. If the difference in the floodable length were 6 per cent., it corresponded to a 4 per cent. increase in the draught of the ship. The author's paper afforded a confirmation that the application of the present rules was somewhat complicated, and this was a further plea for the simplification of the rules.

Mr. W. J. Lovett, replying to the discussion, said that there was little to be commented upon in the remarks. The value of the paper was in the curves presented, the reading matter serving merely as a means of presenting those curves. The curves were upon the Bulkhead Committee's Report, with the exception of the corrections for form, and the latter would be found to vary in every shipyard, each shipyard having its own type of model. The type of model adopted in one yard would take small form corrections from a standard model, in so far as it approached the design of the standard model. If, however, the shipyard took a form of model radically different from the standard form the correction for form would, by that extent, be the greater. The model used by the speaker's firm was closer than was general to the standard. On the permeability question Professor Welch had not thought it possible so to alter the draught of a boat as to give that boat an equal percentage of safety with a permeability smaller than that assumed in the Bulkhead Committee's Report. If a ship were leaving port with the permeability entitling it to a greater draught, it might be permitted to load a little deeper for that voyage. The cruiser stern was undoubtedly handicapped by the method of assuming the length of the ship; if the latter were taken as the centre of the rudder-stock and the bow, and the coefficient made on that length of ship, it would be fairer to take it through the stern. As the paper dealt entirely with the Bulkhead Committee's Report curves, he must refer the questions raised as to stability and strength to that report. As to simplification of rules, the speaker would like such a simplification if it were practicable. Approximate values might be got for the design, but these could not well take the place of the absolute finality to which the ways and means suggested by the Bulkhead Committee pointed. The method put forward in that committee's report, if simplified a little here and there, would be quite satisfactory.

On the motion of the chairman, the author was awarded a vote of thanks for his contribution.

STRESS DETERMINATION IN A FLAT PLATE.

The next paper taken was one on "Stress Determination in a Flat Plate," by Mr. J. Montgomerie, B.Sc.; it was read in abstract by the secretary.

It gives the results of tests made upon a rectangular flat plate exposed to normal pressure over its surface. The plate formed one of a series of varying thickness, experiments upon which were begun in the autumn of 1910, and which have been prosecuted since. They were carried out in the engineering department of the West Ham Technical Institute. We hope to publish this paper with its illustrations in an early issue.

Mr. W. S. Abell, in a written communication, read by the secretary, considered Mr. Montgomerie's paper as the most valuable contribution on the subject so far made to the Institution, and the information contained in the paper would aid design work considerably, particularly in relation to frame spacing and spacing bulkhead stiffeners. The author's note on frame spacing and plate thickness agreed well with empirical practice and the semi-empirical proposal of the Load Line Committee. It would appear that a plate of 0,73 in., relatively thick for shipbuilding purposes, did not behave according to the conception of a plate as a beam fixed at the end. Indeed, such a conception was only reasonable in the case of a deep rigid beam, and was not applicable to ship plates, more or less thin laminæ. It was reasonable to expect the stress at the ends of a plate to be greater than that at the centre. Fig. 33 showed the maximum stress at the middle of the short diameter, the stress at the ends approaching it closely. So far as Mr. Abell was aware the author's measurements were the first to be made directly on the plates, observed deflection being the usual basis of measurement. It also appeared that there was a close relation between the results obtained by deflection and those obtained by direct measurement. In conclusion he would suggest for the author's consideration whether it would not be interesting to take results on other plates in which the variation of deflection with pressure was not an approximately linear ratio; there might be a difference between the centre stress and the stress at the sides.

Mr. J. Foster King, not having been able to read the paper with the attention it deserved, had only seized upon one point, namely, that even under ideal conditions of fixity it was found that the mathematical conditions of fixity, on which most of the formulæ were based, had no foundation in practice; the ideal tests confirmed the full-scale experiments of the Bulkhead Committee, in which both plates and stiffeners were tested under high water pressure, and which showed that there need not be in ship construction anything approaching the fixed end conditions for beams. The paper was a valuable contribution to practical mechanics, and would simplify many difficulties arising out of the conflict between mathematical theory and actual practice.

Professor W. E. Dalby regarded the subject of the paper as one of the most difficult on which to give any practical information to the engineer or designer. The subject had interested him in connection with the determination of the deflection of the circular discs he used for the optical indicator. In that case he had not found the mathematical theory far wrong, but the conditions were very different. The author had dealt with a very large plate, and the mathematical theory of elasticity assumed almost complete uniformity of material, not necessarily found in large plate material coming from the mills. In dealing with high-carbon steel a nearer approach to the material used by the mathematician was reached, and, consequently, the results of theory and practice would be likely to be closer. He was bound to say that the small discs came nearer to the deflection predicted by the ordinary theory of elasticity. In dealing with the discs, however, a small deflection very soon carried the stress in parts of the plate beyond the elastic limit, and success in getting a good scale—an absolutely uniform scale could be obtained—was dependent on keeping the deflection small. It would be interesting if the experiments could be carried to such an extent that the parts of the plate were overstrained, so that the distribution of stress in the overstrained part might be indicated. In many engineering structures such overstrain actually took place; the steel yielded at certain points, and the safety of the structure was probably due to that cause. He hoped the experiments could be continued on other plates, and if there could be added—the apparatus being, he understood, available—overstrain experiments, information of great value would accrue to the engineering profession. There was plenty of data for small discs, and the subject had been gone into very carefully at the Harvard University in America, very valuable results having been obtained.

Mr. J. Duncan explained that the experiments which formed the subject of the paper had been carried out at West Ham, mostly in odd hours, the author's available time for experimenting being greatly limited. The principal point raised in the discussion related to the common assumption, in the case of an *encastré* beam fixed at both ends, that the section of the beam on the plane of the wall before bending remained in that plane after bending; in other words, the beam was elastic only between the supports and was perfectly rigid inside the wall. Actually, the section did not remain within the plane of the wall, and recent experiments had been made by the speaker on *encastré* beams, coupled with measurements of the author's ¾-in. plates, in order

to ascertain how far the assumption was valid for the end of the short diameter (49 in the paper). The speaker found that the section actually came out of the plane of the wall; the plate inside the wall became elastic, just the same as the plate outside the wall.

The chairman called for a vote of thanks to the author, which was cordially responded to.

The Closing of Side Apertures in Ships from the Bridge.

A paper having the above title was then taken. It was contributed by Mr. E. Benvenuti, and was read in abstract by the secretary. We propose to reproduce it in full in a future issue.

Mr. Gilbert read a communication on the subject of the paper in which he commented upon the increased safety of vessels which would follow the introduction of a simple and practical method of closing side apertures from a central point. He desired to point out to the author that a full-sized working arrangement was in existence in November, 1913, but he could not say whether the apparatus could control all the sidelights from the bridge. This device had been approved by the Board of Trade, and had already been fitted to two ocean-going vessels. Further, the slip coupling mentioned briefly by the author was of the utmost importance, and the speaker proceeded to consider the probabilities of the coupling and sliding shutter proving operable in practice. If any large number of shutters were to be worked, amplitude of shaft diameter and the question of torque had to be considered. Numerous other mechanical details were touched upon by the speaker, and the conclusion to be drawn from his criticisms pointed to a belief in the advisability of greater simplicity of construction.

Mr. W. H. Whiting, who followed, said Mr. Benvenuti's paper was a carefully and clearly written contribution. He did not propose to discuss in detail the apparatus the author suggested, but would like to point out that his assuming a heel of 10 deg. pointed to a ship having a low initial stability. The metacentric height of vessels should be increased, and all conditions which tended to increase the heel should be abolished. The tendency that prevailed of giving large passenger ships a low metacentric height was to be regretted. There were already in existence on board ship a number of elaborate apparatus similar to those proposed by the author; for example, for the closing of the watertight doors from the bridge, and he (the speaker) thought it would be undesirable to make them more numerous. The question of the transversal stability of ships had formed the subject of some of the early papers contributed to the Institution, and the author's paper showed that it was not yet exhausted.

On the motion of the chairman the author was awarded a hearty vote of thanks for his contribution.

Apparatus for Interpreting Stability for the Use of Shipmasters.

The last paper taken at Wednesday afternoon's meeting was one on an "Apparatus for Interpreting Stability for the Use of Shipmasters." It was read in abstract by the author, Mr. Thomas Graham, B.Sc. We reproduce it in the present issue (page 299).

The discussion was opened by Mr. W. J. Luke, who said that the author truly pointed out that Mr. Ralston had brought out an indicator for determining initial stability and trim. Now the author told the meeting that his apparatus had been designed to co-ordinate and employ more fully the existing information supplied to vessels, *i.e.*, draught, deadweight and displacement scales, metacentric diagram and stability results. A naval architect, in the narrow sense of the term, could sit at his office and by means of drawings might satisfy himself by figures that the stability of a given ship was satisfactory. What was wanted was that a seaman could obtain confirmation of this, and the apparatus described should be welcomed from this point of view, both by the theoretic man and by the sea-going captain. The apparatus described by the author was theoretically sound and correct.

Captain Ruthven said he had commanded Orient steamers for over thirty years, and had used the Ralston instrument, tentatively at first, and had then taught his officers to use it. He had worked out the questions by figures, but such instruments were no doubt of service to men who were not good at figures and were also of advantage for the checking of figures. Nearly all the ships of his company now had the Ralston apparatus.

Captain Young, who followed, welcomed such instruments for assisting shipmasters and officers in their calculations. When loading all sorts of cargoes, particularly homogeneous cargoes, difficult moments occurred in the work, especially towards the end of the operations, when despatch was required. If, then, an instrument made it possible to arrive at the stability of the ship, it would render a valuable service to the mercantile marine. Time would show whether reliance could be placed on the instrument under all conditions. He would think that the behaviour of the instrument in smooth water would be very different from that in a seaway. He hoped the shipmaster would regard it as a useful adjunct; he would be very sorry if it had for effect to prevent him from using his own judgment, for a practical shipmaster could size up the stability of his ship almost without going into figures. He referred to the recent decision of the Board of Trade in regard to the examination of masters and mates, and to the gradual working-up in the teaching of all questions affecting the stability of ships.

Mr. P. A. Hillhouse expressed the opinion that the author's paper could be divided in two parts, one dealing with a slide-rule and the other with his apparatus. He thought the author dispensed, in regard to the former, with a certain amount of data to make his apparatus more simple. He showed on the blackboard how a slide-rule could be made more useful by combining tables of moments and weights. He thought that a captain using the apparatus containing silk cords would have to go on shore, so as to have a steady platform.

Professor Welch found that the paper was established on quite sound lines, and the method as regarded initial stability was a reasonable one. By using the apparatus he thought an error (if any) would occur on the safe side. He also had an idea that it would be difficult on board to make an accurate use of the apparatus. He noticed that the author had used the term "centre of curvature of flotation"; in the old days this was "centre of curvature of the curve of flotation." The paper was one of a class of which they were glad to have many examples, showing that the younger members were coming forward and displaying their interest in the Institution.

Mr. Graham, who replied, said he had no idea his paper would evoke comment to the extent shown. He was greatly handicapped in not having produced a model which would have set the minds of the members at ease. With reference to using his apparatus, this could be done in a rough sea; the distance between the threads was constant. He now had brass rods, at the top of which the thread acted as a hinge. In regard to Mr. Hillhouse's remarks, he thought of putting forward a slide-rule, but slide-rules tended to mystify masters, who were not accustomed to use them; a multiplication of slides was likely to complicate the question. His scales were all contained together in a co-ordinate form, and his apparatus was for use in harbour before starting and not at sea. In regard to his expression, in reply to Professor Welch's remark, he thought this was as accurate as speaking of a "metacentric evolute." There was no such thing.

The author, on a motion by the chairman, was given the thanks of the members for his contribution.

The Institution again met on Wednesday evening, when Professor Dalby read a paper on "The Strength and Inner Structure of Mild Steel," and Lieutenant Scoble one on "The Design of Pin Joints based on Ultimate Strength." Meetings were also held on Thursday forenoon and afternoon, at each of which three papers were read and discussed; one of these, on "Experiments on the Influence of Running Balance of Propellers on the Vibration of Ships," is produced on page 297. We shall continue the report of the proceedings in our next issue.

(To be continued.)

MAXIMUM PRICES OF METALS.

In pursuance of the powers conferred upon him by Regulation 30A of the Defence of the Realm Regulations, the Minister of Munitions hereby orders that the war material to which the regulation applies shall include war material of the following class, that is to say:—

Wrought-Iron Scrap.

Notice of addition to General Permit, March 22, 1917.

With reference to the above Order, the Minister of Munitions hereby gives notice that the General Permit of November 1, 1916, under the Orders of July 7 and October 31, 1916, shall henceforth take effect as if the war material referred to in the above Order were included in the Order of October 31, 1916, and the following material and prices were specified in the schedule to the said General Permit, provided always that condition 2 of the said General Permit shall not apply to any sale or purchase of the war material referred to in the above Order of this date under a contract in writing entered into prior to the date of this notice.

Maximum Prices above referred to for Wrought-Iron Scrap.

	Per ton. £ s. d.
1. (*a*) Wrought-iron plates and sectional material, ⅜ in. thick and over, each piece separate, reasonably clear of rivets, without any flanged end-plates or circular angles and plates, all suitable for shearing	6 5 0
(*b*) Heavy wrought-iron scrap, ⅜ in. thick and over, including horse-shoes	5 15 0
(*c*) Heavy wrought-iron scrap, ¼ in. thick and over, including heavy country wrought-iron scrap ...	5 5 0

2. To the above-mentioned prices for wrought-iron scrap a sum not exceeding 2½ per cent. on such prices may be added in the case of sales by recognised scrap merchants.

All these prices for wrought-iron scrap are free on rail or free in barge at the nearest convenient siding or wharf to the place where the scrap lies at the time of sale.

With reference to the Orders made by the Minister of Munitions on July 7 and October 31, 1916, applying Regulation 30A of the Defence of the Realm Regulations to war material consisting of certain classes and descriptions of metallurgical coke, pig-iron and steel, and to the General Permit for dealing in such war material issued by the Minister of Munitions on November 1, 1916, the Minister of Munitions hereby gives notice that the said General Permit is modified by the deletion from the schedule thereto of the following words:—

	Per ton net f.o.t. at Point of Purchase. £ s. d.
Relayable rails, 50 lb. per yard and over	10 0 0

And by the insertion in the said schedule, immediately before the maximum basis prices for high-speed tool steel, of the following words:—

Maximum Prices for Second-hand Rails.

	Per ton net f.o.t. at Point of Purchase. £ s. d.
Relayable and other second-hand rails, 50 lb. per yard and over, not being heavy steel melting scrap...	10 0 0

To the above-mentioned price a sum not exceeding 2½ per cent. on such price may be added in the case of sales by recognised merchants.

Rails which have been purchased by a merchant and stored or sorted by him in his stock-yard, and which are sold as relayable rails or otherwise than as heavy steel melting scrap, may be sold by the said merchant at a price not exceeding 12*l.* per ton free on trucks at the merchant's stock-yard, or the nearest convenient siding thereto, but without the addition of the above-mentioned 2½ per cent.

All communications with reference to the above Order should be made to the Director of Steel Production, Room 381, Ministry of Munitions of War, Whitehall-place, London, S.W. 1.

The Grangesberg Mining Company.—The Grängesberg-Oxelösund Traffic Company, which controls the bulk of the Swedish iron-mining industry, estimates the profits for 1916 at 15,500,000 kronor, out of which it is proposed to pay a dividend of 15 kronor per share, against 10 kronor the previous year, when the profits amounted to 11,426,000 kronor, the sum carried forward, 9,509,850 kronor, remaining practically unaltered. As the share capital amounts to 99,702,000 kronor, the dividend for 1916 of 15 kronor per share will absorb almost the entire profits of that year. The company's profits have diminished during the war, a sum of 20,412,000 kronor having been paid in dividends in 1912 and 24,192,000 kronor in 1913; the dividends for the two years were respectively 27 and 32 kronor per share, on a then capital of 75,000,000 kronor. The improved profits on last year as compared with the preceding year are due to higher prices having been obtained for the ore, shipments during 1916 having shown a considerable falling off as compared with 1915. (1 krona = 1*s.* 1½*d.*)

INDUSTRIAL NOTES.

THE Minister of Munitions, in exercise of the powers conferred upon him by the Defence of the Realm Acts, has issued an Order with reference to the manufacture in the United Kingdom of electric lamp glass, and to the purchase and sale of such glass outside the United Kingdom. All applications in reference to the Order should be made to the Director of Optical Munitions and Glassware Supply, Ministry of Munitions of War, 117, Piccadilly, W. 1.

The Minister of Munitions, in exercise of the powers conferred upon him by the Defence of the Realm Acts, has issued an Order with reference to dealings in spelter of all qualities, including sheet and rolled zinc, scrap zinc, hard spelter, dross, zinc ashes, flux skimmings and zinc dust.

All applications for licences should be made to the Director of Materials (A.M. 2.C.), Ministry of Munitions Hotel Victoria, London, W.C. 2, and marked "Spelter Licence."

Every applicant for a licence must state the amount and quality of metal required by him per month, and the use to which it will be put.

Not the least notable development incident to the demand made for shells, says *Canadian Machinery*, has been the steady increase of munitions output by Canada, with its resulting influence on the Dominion's future status in the manufacturing world. In pre-war days the productive capacity of the Dominions in strictly mechanical fields was of a very limited nature, due in part to the fiscal policy which seems to be indispensable to young industrial nations during the early stages of developing their natural resources and consolidating their commercial and manufacturing enterprises. Turning to the reserve strength in men, our contemporary says that the word "men" is somewhat ambiguous now, in view of the successful and increasing employment of women; by successful, it means the utilisation of women's help in such a manner that mutual satisfaction with the results obtained will insure a future continuance whenever and wherever opportunity offers. Among the contributing factors may be mentioned equitable remuneration, facilities enabling their arrival and departure to be made in a manner consistent with reasonably-required custom, and the shortest hours possible that the nature of the work permits. Another most important factor is the mechanical resourcefulness which has been displayed by the staffs of hundreds of factories.

The question of the satisfactory organisation of our factories is reviewed in an interesting pamphlet entitled "Welfare Study, What it is," by Mr. Cecil Walton, which is issued by Messrs. Maclure, Macdonald and Co., Glasgow, at the price of 6*d*. By welfare work, Mr. Walton—who is the manager of one of our large National Projectile Factories—does not imply alone the protection of the interests of women employees, and he is emphatic in his disclaimer that welfare does not merely mean canteens, chairs and pianos; these things, he maintains, are rightful adjuncts, the fringes, as it were, on the garment of proper supervision. Welfare work, embracing such matters, implies the provision of suitable surroundings for the task in hand. It means, he adds, the creation of an atmosphere by which the old-time barrier between employer and employee disappears; it is the surest way to speed-up output, and swift praise, swift blame and punishment are among its essential parts. The recreation and food of employees and ambulance work in the factory are touched upon. The author concludes by a statement to the effect that "Welfare is not luxury. It is a capital investment of combined thought and money, more of the former than of the latter; it develops imagination and ingenuity; it encourages invention; it is the grasping of opportunities for little acts of kindness and discipline every day and every minute in the day. It is the perpetual reminder that 'we pass through this world but once,' and—it pays."

The sixth annual report of the Machine Tool and Engineering Association, which gives also a copy of the report of the sixth annual meeting of the association, contains many points of interest, from which we take the following. The directors of the association had handed in to the Board of Trade Engineering Inquiry Committee a report on the machine tool trade, in which they had made certain suggestions as to the steps that will be necessary on the part of the Government to assist in further developments of the trade. In the course of a speech at the sixth annual meeting, the chairman of the directors, Mr. Alfred Herbert, expressed to the members the satisfaction that was felt by the Ministry of Munitions with the great efforts the trade had made to supply the machinery of which the country was in such bitter need. A year ago the situation was even more difficult than it was to-day; the response which had been made was most gratifying. Mr. H. J. Mackinder, M.P., who was re-elected president of the association, said, with regard to working capital, that he felt the better plan would have been to take the excess profits in form of loans without interest, but to have the money easily available at the end of the war as working capital with, if necessary, certain pooling arrangements, so that industries that had not benefited by the war would also be able to obtain working capital. Of the 100,000,000*l.* excess profits tax, it was the fact that very little had come from firms making munitions, and it was believed that when the tax had been collected from these firms a sum of between 200,000,000*l.* and 300,000,000*l.* would be available. The excess profits tax fund ought to be placed at the command, not perhaps of the existing banks, but of an adequate organisation in which business men would be represented, for the purpose of securing that as quickly as possible the great industrial train might be shunted from the war to the peace line.

In the course of a speech at the annual meeting of Hadfield's, Limited, held in Sheffield last Monday, Sir Robert Hadfield congratulated the country generally upon the very wise action of the Prime Minister in appointing the Right Hon. John Hodge to be the first Minister of Labour. Why this had not been done long ago was a mystery to him, just as he could not understand why the late Prime Minister appeared at a certain famous interview to completely turn down the demand of the business men of this country for a Minister of Commerce. He had heard Mr. Hodge speak four or five times in London, and had been delighted with his clear and sensible utterances. He thought most important results would follow this splendid foresight of the Prime Minister, who had the courage to take the sensible and wise course in making this appointment. In regard to the new Minister of Labour's views on certain debatable matters, from what he had heard him say he, as one of the Cabinet, did not intend to see any more German products enter this country so long as work was wanted at home. Sir Robert agreed most heartily with him. As the labour side of the country had had granted their very proper wish and desire, why could not business men have a Minister of Commerce who would give them, amongst other things, better communication with the outlying parts of the Empire, such as cheap cables? Again, why could not they have an Empire-wide patent—one patent to cover the British Empire, just as one patent in the United States covered 3,000,000 square miles? An increase in such facilities would greatly assist our Empire's development.

Speaking of labour disputes, Sir Robert believed most of them could be avoided, specially in times like the present. Employers who were unreasonable and workmen who were the same were in these times greatly to be blamed. Both the "lock-out" and the "down tools" should be prohibited as a danger to the State. He begged the working men of Sheffield seriously to consider before taking an action which was a danger to the State, for in endangering the State they were endangering themselves.

QUEENSLAND COAL FIELDS.—The Queensland Mines Department has received a report from its experts, who have been boring on the Bowen coalfields for some time, stating that they have now proved that within an area of 1 square mile there are 22,000,000 tons of coal. The electrolytic works at Bowen and the smelters and mines at Cloncurry would be very large consumers of coal were these fields exploited. Bowen and Townsville are the two nearest Australian ports to the Panama Canal, and this coal discovery must increase their importance, from the fact that ships leaving Australia for Panama would have to coal at one or the other of them. There are 500,000 acres of Crown lands on the Bowen coalfield district that can be made available for settlement at once.

HIGH TENSILE *versus* MILD STEEL FOR REINFORCED CONCRETE.—Since reinforced concrete was introduced into this country it has been customary to employ plain round mild steel bars, but Mr. A. W. C. Shelf, in his paper on "High Tensile *versus* Mild Steel for Reinforced Concrete," read before the Society of Engineers at the Geological Society, Burlington House, Piccadilly, W., on Monday, March 5, endeavours to prove that plain mild steel bars are not the best to employ for this purpose, but that greater efficiency and economy is obtained by physically developing mild steel bars, for the purpose of taking out the first yield in the steel, which is useless and has a detrimental effect in concrete. When this first yield or stretch is taken out a higher yield-point is obtained without any injury to the steel, so that it is safer to employ a stress of 20,000 lb. per square inch, (which results in a saving of 20 per cent. in the weight of steel required) than it was to employ a stress of 16,000 lb. per square inch before the steel was physically developed, and for this reason the author of the paper thinks that the existing regulation of the London County Council relating to the stress on steel should be altered to avoid the cramping of industrial progress.

NOTES FROM THE UNITED STATES.

PHILADELPHIA, March 8.

THE steel market is moving upward. The railroad situation is seriously interfering with domestic shipments as well as shipments to points of export. The congestion of material for iron and steel is most serious. Blast-furnaces are unable to fill contracts on account of embargoes and are selling all the iron they can where deliveries are possible. Manufacturers cannot rely on the shipment of their goods for 48 hours in advance. Cars are very difficult to get, and sometimes when cars in abundance are furnished and loaded for shipment an embargo is clapped on. Then the question of demurrage is adding to the cost. Shippers do not know how long their cars will be under demurrage. Connellsville coke advanced for spot up to 15 dols., then fell to 13 dols.; for second quarter delivery coke is 7 dols.; a little more is coming out of the region, but it is not very promising. All large consumers of pig-iron are taking advantage of the opportunity of buying as much pig-iron as they can get delivered. The Pennsylvania Railroad some time ago withdrew its order for 205,000 tons, and is now putting in one for 75,000 tons for 1918 delivery. Open-hearth billets are 65 dols. Railway equipment is being ordered very heavily including rails, structural material and cars. February business amounted to 61,000,000 dols. The bulk of car orders was for domestic roads. There were over 10,000 cars ordered. Japan is still after 50,000 tons of steel in addition to recent orders. All are very urgent. Steel plate is wanted beyond all mill capacity. Prices have reached six cents. It is not contradicted that Japan must have 10,000 tons of steel plate in addition to 13,000 tons recently placed.

TRADE LOSSES OF GERMANY.—It is estimated that since she declared war Germany has lost five billions of trade, says *The Marine Journal*, New York. The loss to the British Empire has been nearly one billion dollars, to France as much, and to Russia half a billion. She has lost in imports from the British Empire, raw materials, produce and manufactures, nearly 600,000,000 dols.; over 700,000,000 dols. from Russia, and from France about 350,000,000 dols. The figures are not exact, adds the American journal, for war trade statistics cannot be wholly accurate. Trade takes underground routes during hostilities, or Germany would have now been prostrate. The leakage into Germany through neutral neighbours may perhaps have been all that has kept her army going.

SOUTH AFRICAN-JAPANESE TRADE DEVELOPMENT.—According to *The London and China Telegraph*, Consul E. A. Wakefield, Port Elizabeth, writes as follows:—For the last two years the imports from Japan into this district have been increasing rapidly. A number of Japanese business men have visited South Africa during the last year or two, and have apparently made a careful study of business conditions here. Their inquiries covered the possibility of the South African market for Japanese products, and they also carefully investigated South African produce, such as wool, mohair, hides and skins, both as to quality and quantity. Some of the leading commercial men in this vicinity profess to see very favourable prospects for the future interchange of trade between these two countries. The imports from Japan have increased from 275,000 dols. in 1909 and 520,000 dols. in 1912 to 1,105,000 dols. in 1915 and to 1,830,000 dols. for the first nine months of 1916. The export trade to Japan is only just beginning, and it is too early to forecast with any certainty how rapid or how extensive this development may prove. Within the past few weeks several shipments of wool have been made, and negotiations for others are under way. Shipments of cattle hides, sheep and goat skins have also been made.

CRUCIBLE TOOL STEEL.—Mr. Roy C. McKenna, president of Vanadium-Alloys Steel Company, at a dinner given to salesmen of this company at Pittsburg Athletic Association Club Rooms, Pittsburg, Pa., January 3, 1917, said that equally important to the composition of the steel as the chemical analysis was the melting, hammering or forging, and rolling. If a steel were melted too long it was spoiled, regardless of chemical content. It must be heated uniformly; neither too fast nor too slow. The importance of hammering crucible and high-speed steel was admitted by all informed on the subject. The rolling of crucible or high speed steel was second in importance only to hammering. Good ingots could be spoiled in hammering or rolling. The crucible process of making steel was the simplest method known, but it was also the most costly. Where quality in steel was desired, steel made by the crucible process was specified. Good grade carbon and alloy steels could be made in an electric furnace. The melting of steel in an electric furnace was cheaper than in crucibles; also, in crucibles, only the purest base materials could be introduced in the mix; whereas in an electric furnace impure and cheaper materials could be introduced, and sulphur and phosphorus could be eliminated in the process of melting. Another advantage of the electrical process over crucible practice was that the chemical contents of the steel could be kept within narrower limits. Crucible steel practice had earned its right to exist from time immemorial (although the most costly) on account of the importance of melting a quality steel slowly and at a uniform heat. He must leave it to others to prove whether or not a mass of three to six tons of steel in an electric furnace could be melted as evenly and uniformly as in a crucible containing not over 80 to 90 pounds. It was his prophecy that as long as tool steel of quality was required, crucible practice would be continued. The electric furnace had its place, and there was no question of the superiority of electric-furnace steel over open-hearth steels.

THE LATE MR. JOHN S. RAWORTH.

By the death of Mr. John S. Raworth, at his residence at Streatham, on Saturday, there has passed away, to the regret of a wide circle of friends, professional and personal, one of the pioneers in the electrical industry. From his forebears he inherited the mechanical instinct, and this was broadened and stimulated by close application to the acquisition of experience in a variety of works, enabling him in after years to tackle with confidence problems of considerable mechanical difficulty in the utilisation of electricity in many original ways. He was largely responsible for the successful application of electricity to ship lighting. He developed greatly the system of public lighting and power stations which has had almost incalculable influence in industrial economy. To the same end he contributed important service in the development of urban and rural electric traction, in the face of great difficulties and handicaps, partly due to legislative restrictions.

Born at Sheffield on February 16, 1846, of a family who had for several generations been workers in iron and steel, he early showed a bent for mechanics, and after his education at the Sheffield and Chesterfield grammar schools was apprenticed, when 16 years of age, to Mr. Edward Hayes, of Stoney Stratford. On the completion of his three years' apprenticeship he passed to the drawing office in the locomotive works of Messrs. R. and W. Hawthorn, of Newcastle-on-Tyne, and continued there for two years. In 1868 he entered the service of Messrs. Wren and Hopkinson, of Manchester, becoming assistant to John Hopkinson, who, with his sons, had a very large influence on the development, from the practical as well as the theoretical standpoint, of electrical machinery. Mr. Raworth was thus brought into intimate association with the beginnings of great things, and his training as a mechanical engineer enabled him to approach problems from a broader standpoint than was then, and is still, too often the case with many electrical engineers. He continued with Hopkinson for four years, during which he did much original work, but more important still, he laid the foundation, by the further acquisition of experience, for the work of greater originality in later years. The breadth of mind to which we have referred was further developed by his association, from 1872 to 1878, with the design and manufacture of machinery for cotton spinning and weaving, than which there is no better medium for cultivating faculties of invention and resource.

It was in 1878 that he began his more important work in the development of electrical machinery, becoming then a member of the staff of Messrs. Siemens Brothers, and for over thirty years he continued active in the application of electricity to a great variety of purposes. His first important work with Siemens was connected with the introduction of electric lighting in ships. There was no more promising field for the new illuminant than that on board ship. Gas had been tried as a substitute for candles and oil lamps, but was a complete failure for obvious reasons. The Inman Line, one of the most progressive steamship companies of that time, welcomed Mr. Raworth's overtures to fit electric light into the City of Berlin, which had been built in 1875. Apart altogether from the fact that the incandescent lamp was not then available, although it succeeded the Jablochkoff candle and the arc lamps later in ship lighting, there were difficulties connected with the system of generating the electricity. The early dynamos were belt-driven, and the arrangement was not convenient in the confined spaces in ships, which precluded the use of a belt of sufficient length. Mr. Raworth's first alternative was to use a continuous rope, upon pulleys with six or eight grooves, bringing the end back from the last driven pulley to the first groove of the driving pulley by means of a guide pulley.* Later, another arrangement was got out for a friction drive with the dynamo hung freely on two pivots so that the main bearings could adapt themselves exactly to the position of the spindle.† These were more or less transitory stages. Later, the high-speed engine directly coupled to the dynamo, of which Mr. Raworth's "Universal" engine‡ was a notable example, overcame the difficulties, although it, in its turn, gave place to the turbine. But he had, in these early days, to devise also fittings, switches, switchboards, casings and the like, because it must be remembered that interior lighting by electricity was then in its infancy. Through all these developments the subject of our memoir may be said to have laid the foundations of many separate electrical trades of to-day.

Although thus engaged in ship lighting, Mr. Raworth was simultaneously occupied in connection with the beginning of public power stations, and for a time ran a small central station in Manchester for distributing current in its immediate neighbourhood. Indeed, with many of the early electrical installations erected in Lancashire he was identified; incidentally, it may be said, he put up the first electrically-operated hoist. In 1886 he joined the Anglo-American Brush Electric Light Corporation, now the Brush Electrical Engineering Company, who had their works in the metropolis, and from this time forward he had a larger field and wider responsibilities. A 50-h.p. dynamo was then about the largest machine made by the Brush Company, but soon immense developments took place, largely as a consequence of the introduction of Mr. Raworth's "Universal" engine already referred to. Many of the London power stations, and those at Leicester, Huddersfield, Hanley, Bournemouth, and other provincial centres, owed the beginning of their electrical supply to Mr. Raworth and his company. A result was that before many years he had the satisfaction of organising and equipping the new works of the company at Loughborough. On the completion of these works he exchanged the position of chief engineer for a seat on the board of directors, and, in addition, took up a consulting practice in Westminster.

He had already become technical adviser to several important electrical undertakings, and among these was the British Electric Traction Company. Through this agency he was drawn into this branch of the electrical industry, and it was in this connection that his mechanical ingenuity found its widest scope. Owing to the socialistic tendency of legislation, involving restrictions on private enterprise in the application of electricity to existing horse tramways, Mr. Raworth also found play for that characteristic dialectic mind which was invaluable in combating the arguments of the "municipal trader." But into this phase of the subject it is not necessary now to enter. Suffice it to say that the result was the application of electric tramways through the enterprise of Mr. Raworth and his colleagues to many small communities long before the larger cities enjoyed this advantage, because the corporations of those cities would not themselves act by purchasing the companies before the expiry of the leases and converting the system to electricity, or by extending the leases of companies to make it worth their while to adopt electric traction. As with lighting, so with traction, Mr. Raworth did much original work, although with the single exception of his regenerative patents his name was never associated directly with these inventions, his high-speed engine, for instance, being always referred to as the "Universal." The records of the Patent Office, however, contain many inventions which have become almost universal practice. They reveal, too, his characteristic line of thought in mechanics, an extremely common-sense one, free from idiosyncracy, from which often arises what can only be regarded as excrescences.

Indeed, one might almost say that in his attack on professional and social problems, meaning thereby all the relations between employer and worker and man and man, common-sense was the dominating note. This was marked, too, at shareholders' meetings, whether he acted as chairman, director or critic. His entry into debate at the technical institutions was always welcomed, as much for the force of his argument, illuminated as it was by appropriate example and apt quotation, largely biblical, as for the sound technical judgment born of experience and knowledge. The same may be said of his writings. He became a member of the Institution of Civil Engineers in 1894, and was also a member of the Institution of Electrical Engineers, for which latter organisation, more perhaps than any other, he did great service. Some years ago, however, he began to relinquish active participation, not only in the institutions but in the electrical concerns with the development of which he had been so closely identified, although in many of them he continued in a consultative capacity. For some months his health had been far from satisfactory, and, as we have said, he died on Saturday last. Wide sympathy is entertained for his widow—Margaret Cannington, daughter of the late Mr. James Kershaw, of Southport—and for his family of two sons and two daughters.

* See ENGINEERING, vol. xxxv, page 425.
† See ENGINEERING, vol. xliv, page 559.
‡ See ENGINEERING, vol. lxi, page 279.

THE RICKMERS SHIPYARD AND SHIPPING COMPANY, BREMEN.—During the war many important changes have taken place in the German shipping and shipbuilding trade, the object in most cases being further amalgamations. The latest deal is the purchase by the National Bank of Germany of the majority of shares in the old Rickmers concern, Bremen, with which the bank in question has had no previous connection. Whether, as has been mentioned, some Westphalian industrial magnate is interested in the deal, thus following the example of August Thyssen and Hugo Stinnes, remains to be seen. The concern has hitherto been entirely owned by the Rickmers family, the share capital being 13,000,000 marks, of which some 10,000,000 marks have been secured by the bank in question. It is understood that it is proposed materially to extend the shipbuilding branch, as Germany will be in need of further shipbuilding berths after the war. The Rickmers yard, so far, had built ships principally for its own use.

METRIC BILL, 1917.

TO THE EDITOR OF ENGINEERING.

SIR,—Mr. Adamson and his friends have always known that no scrapping of plant occurred in any metric country as a consequence of metric laws. Why do they suddenly seize upon this fact as a weapon against the metric system? Why did we hear so little about "persistence of old standards" when manufacturers were being terrorised by pictures of wholesale "metric" destruction of their property, when Mr. Brough told the electrical engineers that the gas pipes were to be torn out of their houses.

Clause 4A of the new Metric Bill having killed their "destruction bogey," they reverse the operation and deride the metric system because it has failed as a destroyer of property and allows "old standards to persist."

As to compulsion and voluntaryism in weights and measures, all history shows that fair dealing comes only with compulsion, especially in the matter of uniformity in weights and measures. Yet we are reminded of our "freedom" to use a new system such as the metric. Some metric enthusiasts have made the attempt, but only a favoured few have succeeded. Such successes are confined to trades which use no raw materials made up to any particular dimensions and whose output is not raw material to any other manufacturer. Even in these cases the success has been minimised by the difficulty of obtaining recognition of invoices and way-bills by the great transport companies.

The query as to bolts is easily answered. In terms of the Bill the following item in an invoice would be quite in order:—

"35 kg. of ⅞ Whitworth bolts at 30*s.* per kilogram, Fl.10.50."

Mr. Adamson's appeal, on behalf of the manufacturers, for a voice in the matter is surely belated in these days of questionnaires.

As in political matters, most business men are indifferent or afraid to speak. The most recent attempt to get the "voiceless" manufacturers to speak up gave 3,000 replies to 25,000 circulars issued. Out of the replies 99 per cent. were favourable to the metric system.

Yours truly,
EDWARD C. BARTON.

Royal Societies Club, St. James's-street, S.W. 1
March 28, 1917.

WIND PRESSURE.

TO THE EDITOR OF ENGINEERING.

SIR,—With reference to Mr. Tomlinson's letter on the above subject, in your issue of March 23 last, I fully agree with him that wind pressures usually adopted are excessive. There are other examples where wind pressure has been entirely ignored, with no serious result; though in some of these it would have been better to have provided for some amount of wind pressure.

I consider that 30 lb. pressure per square foot is excessive in exposed situations, but this is the figure I have adopted for all my buildings on promenade piers.

I shall only mention, as illustrations, the pavilion on Eastbourne pier, which I designed 15 years ago, and the new concert hall on the West Pier, Brighton, completed a year ago. The latter has arched roof trusses of 70 ft. span. These buildings show no weakness in the heaviest gales, and no one can say that their situation is otherwise than fully exposed to the full force of the gales.

Yours faithfully,
M. NOEL RIDLEY,
M.Inst. C.E.

6, Clova-road, Forest Gate, E, 7, March 28, 1917.

"THE WESTERN FRONT."—Part IV of "The Western Front" contains drawings by Mr. Muirhead Bone of the interiors of large numbers of munition works, and of tool and mechanical operations therein. It has also sketches executed at the front in the neighbourhood of "No Man's Land." The work is issued in monthly numbers from the offices of *Country Life*, at the price of 2*s.*

TRANSFORMERS FOR ELECTRIC RAILWAYS.—On monophase railway systems a threefold current transformation takes place as a rule between the generating station and the engine motors. The last of these three transformations is effected on the engine, and there the volume and weight of the transformer are important factors. Yet the literature on electric railways says very little in general on the volume and weight of iron and copper, on the magnetising current, the iron and copper losses, and the ratio of maximum to permanent load, even in otherwise full descriptions of electric railways. This complaint is made by Dr. W. Kummer, of Zürich, in an article on "Alternating Current Transformers for Electric Traction," contributed to the *Schweizerische Bauzeitung* of March 10. Dr. Kummer particularly wishes to know whether he is right in assuming, in his deductions, that the transformer constant is substantially the same for dry, air-cooled and for wet, oil-cooled transformers. His general expression for this constant is $V = C \cdot (E \cdot I)^{\frac{1}{2}}$, where V is the active transformer volume (the sum of the volumes of the iron and copper); E and I are the volts and amperes supplied, and C is the transformer constant. If the assumption be confirmed, then the preference for the more expensive oil insulation would be justified only by the greater safety of working, and Dr. Kummer makes an appeal for reliable data to settle this and other points.

THE NEW COAL TAX IN GERMANY.

THE new tax on coal and kindred products naturally attracts much attention in Germany, as it is a fairly drastic measure. It is intended to levy a tax of 20 per cent. on (1) coal and lignite at the works; (2) coal in coke at the works; (3) coal in coal briquettes; (4) lignite briquettes; (5) foreign coal on its value at the frontier; and (6) foreign coke. No tax is to be levied on coal consumed at the collieries. The output of the large Harpen coal-mining concern, for instance, during 1915–16 brought in about 100,000,000 marks, on which the new tax would amount to 20,000,000 marks. The 450,000–500,000 tons of coal which the company's 22 mines require for their own consumption —about 7 per cent of the total production—are free from taxation.

There is some apprehension that the mines may even attempt to levy more than the actual tax on the consumers; thus, for instance, mines which also sell coke could raise the price both of coke and by-products to make good the tax paid on the coal used for coking.

The possible rise in the price of coke may also give a fresh impetus to combines of iron works and coal mines, just as did the traffic tax, which does not apply to the private lines of iron works and coal mines. The question of the price of by-products from the coke is likely to cause some difficulties. Thus the future price of sulphate of ammonia will no doubt be influenced by the high prices ruling for nitrates and the unfavourable German exchange, and the more of the coal tax a works can put on to the different by-products, the cheaper becomes the coke for its own blast-furnaces, as well as the gas for works and plant.

Lignite briquettes are placed on a different footing, inasmuch as in this case the finished product, and not the raw material used, is taxed. As the briquettes cost two or three times as much as the raw material at the works, it is quite possible that the further increase which the tax means may tend to increase the use of raw fuel, which had been generally and somewhat forcibly superseded by briquettes.

The coal tax is expected to realise a revenue of 500,000,000 marks per annum, and in this connection the estimated value of the German production of coal and lignite during the years 1913, 1914 and 1915 is stated to have been as follows:—

		Tons.	Marks.
	1913.		
Coal	... ...	190,109,440	2,135,578,000
Lignite	... ...	87,233,084	191,920,000
	1914.		
Coal	... ...	161,535,000	1,776,885,000
Lignite	... ...	83,947,000	193,078,200
	1915.		
Coal	... ...	146,712,000	1,797,222,000
Lignite	... ...	88,370,000	220,925,000

The increase of value of lignites by being pressed into briquettes amounted in 1913 to 51,153,000 marks, in 1914 to 50,000,000 marks, and in 1915 to 58,000,000 marks.

It has been contended that the tax ought to be levied according to weight, but this system would act unfairly. Thus in the year 1913 the average value per ton of coal raised was 9.8 marks for Upper Silesian coal and 13.47 marks for the Thuringian coal district, whilst for lignite the value ranged between 1.35 marks for the Upper Pfalz district and 6.63 marks for the Westerwald district, and, counting the high-class Bavarian pitch coals, which are also lignites, even 13.10 marks. If 500,000,000 marks had to be raised per annum by a weight tax, say, of 2.50 marks per ton of coal and 0.85 mark per ton of lignite, this would mean, in percentage of the value, for the Upper Silesian coal district, 27.5 per cent.; Thuringian coal district, 18.5 per cent.; Upper Pfalz lignite dsistrict, 63 per cent.; and Westerwald lignite district, 13.6 per cent.

The Imperial Government has therefore decided upon a tax on the value, and this value will be arrived at according to industrial-commercial and not technical views. Of the coal liable to tax, about 70 per cent. is sold, the bulk of the rest going to coking works and other auxiliary industries; of the lignite, including briquettes, the corresponding figure is about 90 per cent.

THE NORTH GERMAN LLOYD.—At the commencement of the war the company boasted a fleet, afloat or in course of building, of 102 ocean-going steamers, 40 coasting steamers, 68 river steamers and 283 lighters. From the beginning of 1914 until the war broke out the company's steamers carried about 400,000 persons, and in the whole of 1913 an aggregate of between 600,000 and 700,000 passengers. The war has entirely upset its regular trade, but still the company has exerted itself in other ways. Since 1914 it has taken over 10 vessels in course of construction, with an aggregate tonnage of 70,000 tons gross, and there are still 8 steamers being built, of an aggregate tonnage of 136,000 tons gross, including the Columbus and the Hindenburg, each of 35,000 tons gross. Of the company's 25,000 employees, some 6,000 men are serving at the front or in the navy.

METAL MELTING AS PRACTISED AT THE ROYAL MINT.*

By W. J. HOCKING.

A BRIEF general account of the melting branch of the Royal Mint and its work might form a suitable preface to this paper.

In this branch bars of the various coinage alloys are cast, preparatory to rolling. The metals used are usually procured in the form of fine ingots, and are alloyed in the proportions shown in the following statement:—

Standard gold: 91⅔ per cent. gold; 8⅓ per cent. copper.
Imperial silver: 92½ per cent. silver; 7½ per cent. copper.
Coinage bronze: 95 per cent. copper; 4 per cent. tin; 1 per cent. zinc.
Cupro-nickel: 75 per cent. copper; 25 per cent. nickel.

In addition to the fine ingots and alloy the average charge, to the extent of about one-third of the total, consists of scrap metal from the various processes of manufacture, returned for melting.

The bars cast are about 2 ft. long, but differ in width and thickness according to the denomination of coin desired. The width varies from 4 in. in the case of bars for bronze coins to 1¼ in. in the case of those for threepences, and the thickness from ⅜ in. for cupro-nickel bars to ⅛ in. for bars for bronze. The bars are rolled in another department to the thickness of the coin required.

The average weight of the various classes of coinage metals cast annually during the last five years was about 2,000 tons, or a mean rate of a little over 7 tons (7,000 kg.) for the working day.

In melting gold and silver tor coinage work, great care must be taken to secure in result the correct proportions of metals in the alloys as they are legally prescribed. The limits of variation from exact fineness are narrow, and are specified in the Coinage Act of 1891 (54 & 55 Vict., c. 72) as two parts per thousand for gold and four parts per thousand for silver. The variations permitted in practice are much less than these, and the necessity that the bars cast should be uniform in composition tends to restrict the size of the charges. The volume of the charge is mainly determined by the convenience of stirring it when molten and before pouring. Gold and silver bars are isolated in their respective "pots" until they are reported by the assayer to be either suitable or unsuitable for coinage. The usual charge of standard gold is 2,800 oz., or 87 kg., and of silver 6,000 oz., or 187 kg.

Two sets of furnaces are erected in separate rooms, the set of smaller furnaces being reserved exclusively for melting gold. The set of larger furnaces is used for melting silver, bronze and cupro-nickel, crucibles of the same size being used for all three metals. About 400 lb., or 182 kg., is the weight of the charge of each of the two baser metals.

Reorganisation of Melting Plant.—Owing to a steady increase in the demands upon the Mint in recent years for coinage, it became necessary to extend the capacity of the melting branch as well as that of other operations of coinage. It was not possible to enlarge the rooms for melting without a complete reorganisation of the whole branch. Accordingly, the site was cleared, and new buildings were erected during 1910 and 1911. The furnaces were rebuilt and adapted for gas fuel in substitution for coke. First of all, however, a protracted series of experiments was made with various classes of fuels and burners, and the most satisfactory results as to speed of melting and economy of cost were obtained by the use of coal gas at low pressure. These experiments numbered over 250, and were made with 19 different burners for oil and for gas, most of the burners being tried under various conditions of air and fuel pressures.

Unexpected circumstances arising during the transition period necessitated the adoption of experimental furnaces on a magnified scale. On the assumption that gold coinage would be suspended for a considerable period, the gold-melting house was transferred to the builders early in March, 1910. Before the end of the month, owing to public demands, an immediate resumption of gold coinage became imperative. Acting upon results of experiments made with oil and gas in 1909, four (subsequently increased to five) gas-fired furnaces were erected in a disused smithy. This small workshop, only 860 sq. ft. in area, was provided with the usual fittings required in connection with the casting of gold bars for coinage, and was occupied for that purpose from May, 1910, to March, 1912.

A view of this improvised melting house is given (Fig. 1), showing the four furnaces and the general arrangement of the room.

The coinage demands proved heavier than usual, and during this period 874¼ tons of standard gold of the value of 111,199,403*l.* were melted, the average melt for a working day being 1.829 tons (1,858 kg.), or 232,634*l.* in value. In spite of drawbacks due to successive modifications of the new burners and to inexperience with gas as a fuel, the rate of out-turn was much accelerated as compared with former rates obtained with coke fuel. Although the total amount required for coinage was considerably in excess of the usual demands, a high rate of output per furnace was maintained throughout the period, and it was found possible with fewer furnaces to supply the rolling-mills with sufficient bars. For the 10 preceding calendar years the average annual production from eight coke-fired furnaces was 191 tons, while in 1910–12, with four (five for part time) gas-fired furnaces, the annual out-turn was 437 tons, the crucibles used being increased in size in the latter period. The bars produced showed a greater uniformity in composition and a decrease in the rate of waste in melting. A special test occurred in October, 1910, of the efficiency of the four experimental furnaces during a long run which extended continuously throughout 27½ hours. The total amount of gold melted was 257,052 oz., or 7.87 tons (7,996 kg.), which is upwards of a million sterling in value. There were 102 pourings, and the consumption of gas was 32,000 cub. ft.

New Furnaces for Melting Silver and Bronze.—The larger of the two new rooms for melting operations was completed before the close of this probationary period in the smithy, and work was commenced therein in January, 1911. Fig. 2 is a plan of this room and shows the general arrangement of the plant. The room measures 105 ft. by 52½ ft. Sixteen furnaces are constructed in line towards the centre of the room, arranged in two batteries, one of ten, measuring 34 ft. by 4 ft. 6 in., and one of six, measuring 21 ft. by 4 ft. 6 in.

The furnaces are built of Stourbridge firebrick, each well being 19 in. in diameter and 32 in. deep. The wells are lined with circular bricks, 3 in. thick, jointed with a refractory material composed of carborundum, firesand and silicate of soda, which is also used as a backing for the bricks. The face of the bricks forming the interior of the wells is treated with a wash made up of the same materials. The whole mass of brickwork is braced together by a framework of iron bars to resist expansion, but is not enclosed with iron casing.

For convenience of charging the furnaces and of access to the crucibles for stirring the contents, the furnaces stand 27 in. above the floor-level. The tops are covered with cast-iron plates, 1 in. thick, bedded upon a ¼-in. layer of asbestos cement. The plates are fitted loosely in sections to admit of expansion, and are shaped to allow a lip of brickwork around each furnace hole, 4½ in. broad. The ring of brickwork is made to rise slightly above the level of the iron tops, and serves to prevent the fusion of the iron coverings. The tops were at first carried to the edge of the furnace holes and the molten iron scored the face of the furnace linings, necessitating frequent renewals. A circular firebrick, 27 in. in diameter and 3 in. thick, is used to close the mouth of the furnace hole during melting. This cover is surrounded by two semicircular iron bands, ⅜ in. thick, bolted together to form a frame. The cover, which weighs 1¼ cwt., is lifted and wheeled into any desired position on the furnace top by means of a portable cover remover, designed in the Mint, and shown in plan and elevation in Fig. 3. The two ends of the lifter engage with a couple of lugs at opposite sides of the frame of the cover. A long detachable handle fitted with a socket serves to raise and guide the cover in the required direction, an operation easily performed from the back of the furnace. One of these tools is provided for each pair of furnaces.

An electrically-driven overhead travelling crane of 5 cwt. capacity hoists the crucible of molten metal from the furnace and transports it to one of two pouring frames (Fig. 1). The movements of the crane are directed by means of switches situated at two platforms shown in the plan (Fig. 2). When in position for pouring the crucible is gradually tilted by worm gearing connected with the frame through the quadrant of a circle, and the contents poured into iron moulds. The moulds are set up in batches of about forty in wheeled carriages, which travel on a permanent track laid lengthwise of the room, with a turntable and side-track at one end (Fig. 2). During the process of pouring the forward motion of the carriage on the rails as the moulds become full, as well as the upward movement of the crucible, is secured by rack and pinion gearing attached to the frame, the motions being actuated by separate wheels, controlled by two workmen. Fig. 4 is a photograph giving a general view of the centre of the room, showing the position of the furnaces, travelling crane and pouring frame.

Fuel Supply and Combustion.—Experience gained with the use of gas fuel in the temporary gold-melting house, to which reference has already been made, pointed to the desirability of securing a liberal supply of gas at a constant pressure. The supply of gas under these conditions was undertaken by the Commercial Gas Company, and a 12-in. street main was laid to the meter-house, where four meters, each of 1,000 light capacity, were installed, one to act as a reserve. From the meter-house a 9-in. service main supplies the melting houses direct, and the consumption of gas in melting operations is readily ascertained.

In the large house (Fig. 2) the gas is delivered at the furnaces through a 6-in. service pipe at a steady pressure of 3 in. of water at the furnace. As the total consumption of the 16 large furnaces is about 15,000 cub. ft. per hour, the provision for delivery is well in excess of the requirements. An ample reserve is considered essential to uniformity in results.

Three rotary blowers of the Reichhelm type, obtained from the American Gas Furnace Company, are used to supply air for the burning mixture (Fig. 2). Each blower is capable of delivering 36,000 cub. ft. of free air per hour at 2½ lb. pressure. All the pressure blowers are motor-driven, and two are coupled to feed the larger battery of 10 furnaces. The maximum horse-power required to supply air under pressure for the whole of the furnaces in the large room is 45.

The air and gas are supplied by pipes laid below the ground-level in a trench running parallel with the back of the furnaces. The sizes of these pipes are sufficiently large to admit of one or more furnaces being thrown in or out of action without disturbing the steadiness of the supplies of the remainder; that for air is 9 in. and that for gas is 5 in. to the larger battery, and 4 in. in diameter to the smaller. Connecting pipes from each of the two services are attached to a horizontal girder for support, and conduct the air and gas into a mixer devised

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* Paper read before the Institute of Metals, Thursday, March 22, 1917.

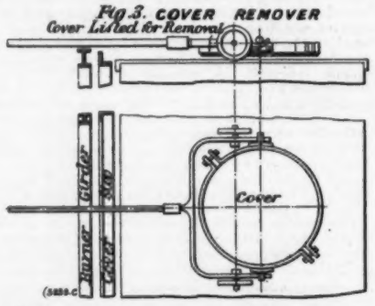
by Brayshaw. A sectional drawing is shown by Brame,* but the pressures for gas and air respectively stated thereon do not correctly describe the Mint working conditions, which are 3 in. for gas and 2½ lb. for air. Check gauges are in use to determine whether the pressures are obtained at the furnaces.

Fig. 7 is a sectional elevation of the furnace, showing the crucible, muffle and cover, the gas and air pipes, with nozzle and burner brick in position, and the main flue, with its connections. Fig. 5 is a back elevation, showing the gas and air pipes, with quadrant taps, and the girder support.

Fig. 6 is a plan of two furnaces without their covers, each containing a crucible. One shows the top view with flue; and the other the bottom with nozzle and burner brick.

The admission pipes to the mixing chamber are governed by valves, the levers of which move over a graduated quadrant. With well-constructed taps of this description the supply of gas and air can be regulated with precision. In the course of a heat these supplies require adjustment as the temperature rises in the furnace. From the mixing chamber the gaseous fuel passes through a right-angled elbow pipe, 2½ in. diameter, to the furnace. To adjust the length of flame to the capacity of the furnace and secure greater melting efficiency, the internal diameter of this pipe was reduced at its extremity to 1¼ in. The method of inserting the nozzle of the burner into the wall of the furnace, illustrated in Figs. 8 and 9, is the one yielding most satisfactory results. This method, which is regarded as essential with this class of furnace to an economical use of gas fuel, was gradually evolved in the Mint, and was finally adopted in May, 1912, as the result of a series of successive modifications.

An 8-in. end-piece, screwed in position and having a



diminishing bore, forms the nozzle (Fig. 8), which is increased to 4 in. in outer diameter at its extremity, and consequently presents a thickened ring of iron to the firebrick. It is easily detached and renewed in the event of corrosion or partial fusion. It may be mentioned here that the effective combustion of the gaseous fuel appears to be aided and the amount of noise reduced by the use of pipes and connections with a perfectly smooth interior. To maintain this condition the mixing chamber and the delivery pipe to the furnace are periodically removed and cleansed from any accumulations of deposit.

The ignition hole of the furnace consists of a perforated firebrick of special shape, as shown in the sectional drawing given in Fig. 9. A circular recess, 4 in. in diameter, at the back of the block, which is 9½ in. square, receives the iron nozzle, which fits the recess closely and is surrounded by asbestos packing well rammed in. The comparatively large block of firebrick serves to keep the nozzle relatively cool. At the bottle-neck the inlet is 1¼ in. in diameter, corresponding with the bore of the burner. The passage then opens out at an angle of 30 deg. into the well of the furnace, where ignition takes place.

The burner block is built into the brickwork, and is set to one side of the horizontal axis of the furnace well in a position to induce the flame to pass between the crucible and the side of the furnace without impinging upon either.

The crucible, which is of the Morgan Salamander type, and of a special mixture adapted for use with gas fuel, is placed centrally in the furnace upon a graphite stand, 10 in. in diameter and 2½ in. thick.

A plumbago or muffle collar, 8 in. deep, rests on the crucible to increase its initial capacity, but no cover is used for the charge during melting in the case of silver and the baser metals. About 3 in. clear space is allowed round the crucible at its greatest diameter to admit of the lowering of the tongs which lift it from the furnace for pouring. When the furnace is closed the top of the muffle is within 2 in. of the cover.

The gas flame, on leaving the ignition hole, travels round the crucible in an upward double spiral. The best results in economy and efficiency are obtained when combustion is complete in the furnace itself, no flame being emitted under the furnace cover nor carried into the flue aperture. To compensate for the lengthening of the flame which takes place as the temperature in the furnace rises during the progress of the melt, the supply of gas and air is regulated by means of the quadrant taps already mentioned. Similar adjustment to maintain the correct mixture becomes necessary in the event of any variation of the gas or the air from normal pressure.

The flue aperture is 4 in. by 2 in. in sectional area, with its axis 5 in. below the iron covering plates, and opens into a horizontal duct leading from the furnace to a vertical shaft, 6 in. square, which serves for two furnaces. This shaft is connected with the main flue, constructed below the floor-level. The main flue (Fig. 7), which runs parallel with the line of furnaces, is 3 ft. by 3 ft. in section, and, before entering the chimney shaft, which is 60 ft. high, it passes through a condensing chamber provided with baffles to intercept any solid matter carried off by the flue gases.

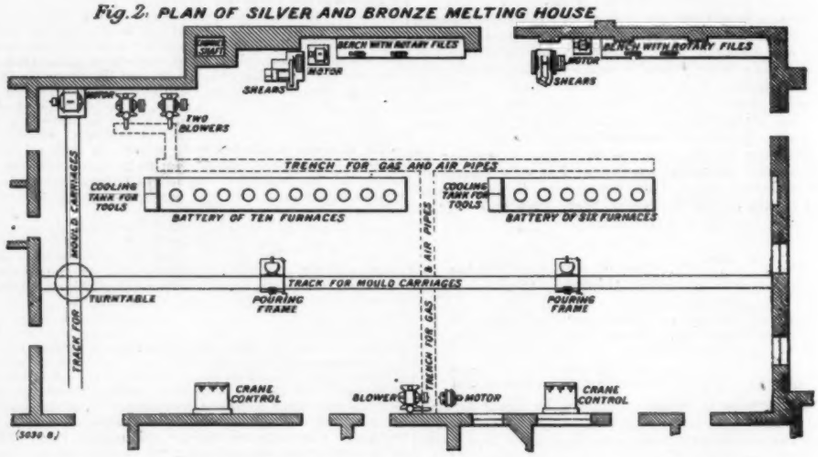
Furnace Management.—For the prevention of accidents in the use of the large volumes of gas and air delivered to the furnaces, a recognised system of workshop procedure was necessary. The following routine was found from the first to work satisfactorily. All the air valves are opened, and the blower is then started to deliver air to the furnaces. Then, dealing with each furnace successively, the air valve is closed, the gas valve opened, the gas ignited, and the air valve reopened to its utmost capacity. So soon as the whole series of furnaces is alight the gas and air taps are adjusted to produce the proper burning mixture in each case.

In shutting off a single furnace the gas valve is first closed, and then the air. When dealing with the whole battery the gas valves are closed on all the furnaces, the pressure blower stopped, and the quadrant taps turned off.

Should the blower stop unexpectedly through the breakage of a belt or from other causes, all gas and air taps are closed immediately to prevent the suction of gas into the air pipe when the pressure is removed and the formation of an explosive mixture. In view of this emergency the air pipes are, in some cases, provided with non-returnable valves, which are automatically brought into action as soon as the pressure ceases. Experiments are in progress to ascertain the simplest and most effective form of safety device for such a contingency.

The furnace linings receive close attention, which is repaid by a lengthened life. The surfaces are kept free from excrescences which would obstruct the free passage of the gas flame. Accumulations of slag at the bottom of the furnace are cleaned out at frequent intervals. Faults in the brickwork arising from the alternate heating and cooling, or from other causes, are patched

FIG. 1. IMPROVISED MELTING HOUSE.



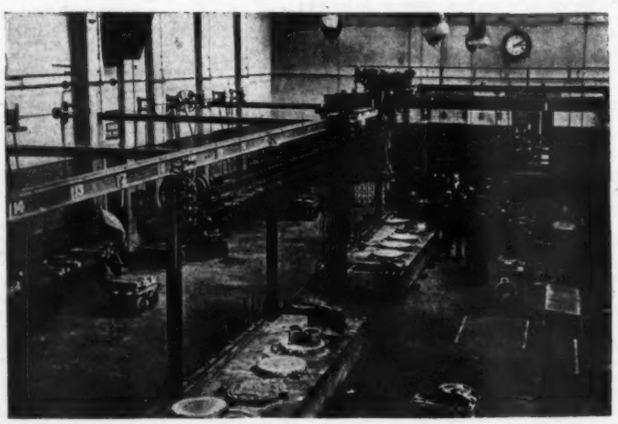


FIG. 4. VIEW OF SILVER AND BRONZE MELTING HOUSE.

* "Fuel: Solid, Liquid, and Gaseous." Arnold, 1914. Fig. 31, page 200.

immediately. In general result the entire lining of a furnace is renewed two or three times a year.

Ventilation.—Provision is made for the ventilation of the melting house by means of fans. Three Blackman fans, situated one at each end and one at the side, are installed near the roof. These can be used either for supply or exhaust, as required. If two of the fans are drawing from the room, and one is discharging into it, the whole volume of air is changed every five minutes, independently of the doors, windows and skylight. It is possible, therefore, to keep the room clear of the fumes which arise, especially during pouring, and also to maintain the general temperature of the workshop at a reasonably low level. The latter becomes a particularly important consideration during the melting of bronze and cupro-nickel in the hot weather, and bears directly upon the efficiency of the workmen. But the flue accommodation itself is amply sufficient for the removal of any products of imperfect combustion, should these occur in the furnaces, and no inconvenience in this respect has at any time arisen in the melting houses.

Comparison of Costs of Melting.—Records are kept in the department of the results of melting with gaseous fuel for comparison with similar results obtained with coke. These results are available for a period of five complete years ended March 31, 1916, in the case of gas, and for five calendar years ended December 31, 1909, in the case of coke. The periods named cover extensive operations. During the five years 1911–16 nearly 10,000 tons (over 10,000,000 kg.) of metal were melted and cast into bars for coinage with a total consumption of 121,000,000 cub. ft. of gas.

A comparison of the records for the two periods shows an economy in favour of gaseous fuel under each of the following heads :—

1. Rate of output.
2. Cost of fuel.
3. Cost of graphite goods.
4. Cost of labour.

1. *Rate of Output.*—Except in the case of gold, crucibles of the same capacity as formerly were used, but the time required for the heats was shortened considerably. The rate of output per furnace in the working day was correspondingly increased, and this increase was especially noticeable in the case of the metals requiring the higher temperatures. In 1909 and in 1913 the largest amounts of cupro-nickel were melted, and, as these metals form the most stringent tests to which the Mint furnaces are subjected, the results of these years are selected to show the comparative rates of out-turn.

Metal.	Average Melt per Furnace per Working Day of Ten Hours.		Increased Output per Furnace.	
	1909 (Coke Fuel).	1913 (Gas Fuel).		
	cwt.	cwt.	cwt.	per cent.
Gold	5.2	9.8	4.6	88.5
Silver (bars for shillings) ..	5.7	12.8	7.1	124.5
Bronze ..	5.2	13.4	8.2	157.7
Cupro-nickel ..	3.6	9.6	5.8	161.1

The same furnaces are used successively for melting silver, bronze and cupro-nickel. As these alloys have melting-points varying more than 200 deg. C. between the maximum and minimum, the greatest economy is not effected in all cases. The rates shown would no doubt be further improved if it were possible to allot a suite of furnaces to each metal, and to modify the burners according to the temperature required to melt each class of metal.

2. *Cost of Fuel.*—The respective costs of coke and gas are well known to vary considerably in different localities. They are also liable to vary in the same locality throughout a given period, although there is a fairly constant relation between the cost of one as compared with the cost of the other. During 1905–9 the price of best foundry coke delivered broken for use at the Mint fluctuated from 35*s.* as a minimum to 42*s.* 4*d.* per ton as a maximum; while during 1911–16 the discount price of gas per 1,000 cub. ft. varied only very slightly from 21*d.*, except during nine months of 1915–16, when it was 18.2*d.* Although the price of gas advanced 12½ per cent. during the last five years, the net cost to the Mint remained practically stationary owing to the sliding scale of discounts allowed by the Commercial Gas Company.

On the total expenditure for fuel for the two periods of five years a cash saving of 3½ per cent. on the amount consumed per ton melted is shown for 1911–16. The amounts melted and the fuel consumed for the two periods are shown side by side :—

	1905–9.	1911–16.
	Tons.	Tons.
Gross amount of metal melted	4,833	9,899
		Cub. ft.
Total consumption of fuel	2,677	121,000,000
	Cwt.	
Consumption of fuel per ton melted	11	12,220
Cost of fuel per ton of metal melted	21.3*s.*	20.58*s.*

The above comparison is made on the basis of the gross amount melted. Owing to the general practice of melting two or more metals simultaneously, it was not possible to secure an extended series of records of the fuel consumption for one metal alone. None whatever are available for the coke period. The following rates of consumption for the various metals are approximately true for gas, but, being based upon readings for comparatively short runs, are subject to revision. The approximate specific gravities and temperatures of pouring are added in the table, as these are essential factors in the relative consumption of fuel.

Metal.	Approx. Specific Gravity.	Approx. Temperature of Pouring. Deg. C.	Cub. ft. of Gas used per Ton Melted.	Cost in Shillings per Ton with Gas at 21*d.* per 1,000 cub. ft.
Gold ..	17.3	1,150	7,000	12.25
Silver ..	10.35	1,090	12,000	21.0
Bronze ..	8.9	1,165	14,500	25.375
Cupro-nickel	8.8	1,300	22,000	38.5

3. *Cost of Graphite Goods.*—The crucibles used for both the coke-fired and the gas-fired furnaces were of the Morgan Salamander brand, the mixture being modified in the latter case to suit the firing. A considerable extension of life was found when they were used with the gaseous fuel. In addition to minor causes, this was mainly due (*a*) to the greater uniformity of combustion in the furnace, and (*b*) to the absence of abrasion to the soft skin of the heated crucible, which is unavoidable during the periodical poking down of the fuel in the coke furnace.

The total inclusive costs for the two periods are placed side by side, and show that the rate per ton melted has been reduced by about one-third.

	1905–9. (Coke Fuel).	1911–16. (Gas Fuel).
Weight of metal melted	4,833 tons	9,899 tons
Total cost of crucibles, &c.	£9,625	£13,295
Cost of crucibles per ton melted ...	39.8*s.*	26.8*s.*
Rate of reduction in costs	—	32.6 per cent.

The figures for costs shown cover in each case the purchase of muffles, covers, stands and stirrers as well as of crucibles. In the latter period the total amount includes advances in price due to the war, and also extra costs incurred in the earlier stages before the manufacturers supplied crucibles specially suited for use with gaseous fuel. The mixture now employed gives excellent results. The improvement in the quality of the crucibles is reflected in the reduction in the rate of cost per ton melted. Comparing the years 1911–12 and 1915–16, the first and last years of the gas period, the drop was from 37*s.* to 22.7*s.* per ton melted, and comparing the five years 1905–9 (using coke) with last year, 1915–16 (using gas), the reduction was from 39.8*s.* to 22.7*s.*, or about 40 per cent. The two tables on page 312 are compiled to show the total costs for fuel and for graphite goods, as well as the average rates of these per ton melted, for the several years of the two periods under review.

4. *Cost of Labour.*—Coke fuel necessitates considerable handling; gaseous fuel is delivered at the furnace without manual labour. During 1905–9 the average annual consumption of coke was 535 tons. Two men were employed in each melting house to transfer the coke from the store to the furnaces as required and to remove the ashes and clinker. This labour, as well as that of periodically feeding the furnaces, was abolished with the introduction of gas fuel. The coke store, which was 37 by 12 ft., was no longer required for this purpose, and this valuable floor space was embodied in the main furnace-room. Ashes and clinker were ground and washed for the recovery of the precious metals. With gas fuel the grinding and washing is confined to crucibles and furnace linings, and the bulk for treatment is considerably reduced in consequence. The weight of the grindings for each 100 tons of gold and silver melted under the two systems is estimated to be as follows :—

	Gold. Tons.	Silver. Tons.
With coke fuel	4.3	3.0
With gaseous fuel	1.3	0.5

Viewing the staff as a whole, the number of men required for a given out-turn of coinage bars was reduced by the change of practice at the rate of about 20 per cent. :—

	1905–9.	1911–16.
Average annual melt	967 tons	1,980 tons
Average number of men employed ...	16.2 men	27 men
Average number of men per 1,000 tons melted	1.68 men	1.36 men
Rate of reduction of labour	—	19 per cent.

A comparison of the actual expenditure for the two calendar years 1909 and 1913 was made under three headings, viz., Fuel, Crucibles and Wages, the money value of which can be most readily ascertained. The result showed a saving in the latter year of 22.8*s.* per ton, or 27.6 per cent. of the total cost in 1909. This economy on the year's melt of 1,958 tons, at the average rate of 22.8*s.* per ton, amounted to 2,232*l.* For this comparison piecework wages, which vary with the rate of output, are excluded, and only standing wages, which vary with the amount of labour required, are stated.

The chief item of cost occurring with gaseous fuel but not with coke arises in the provision of power for the pressure blowers. This item, however, is a comparatively small one. In the large room the electric current supplied is at the rate of 2 Board of Trade units per furnace-hour. The all-round cost for power is estimated to be at a rate not exceeding 2*s.* per ton melted, taking the current at 2*d.* per unit. This item has not been

Fig. 5. B BACK ELEVATION

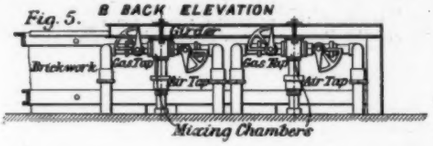
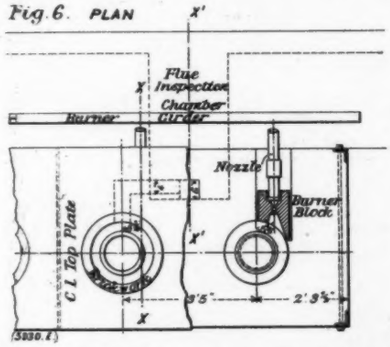
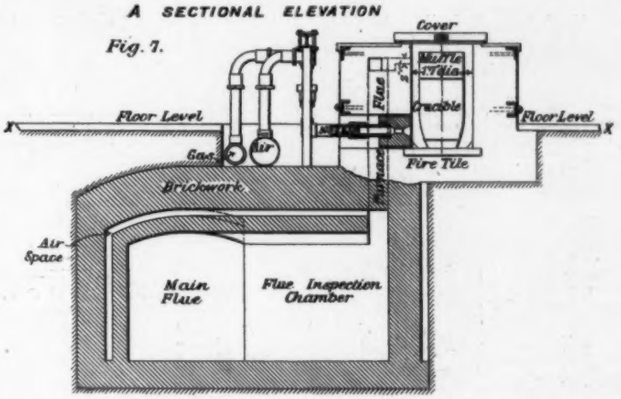


Fig. 6. PLAN



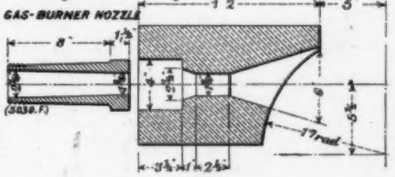
A SECTIONAL ELEVATION

Fig. 7.



FIREBRICK BURNER BLOCK

Fig. 8. Fig. 9.



COSTS FOR FIVE YEARS (1905–9) WITH COKE FUEL.
(*Fuel and Crucibles.*)

Period.	Weight of Metal Melted.			Expenditure.			Cost per Ton (Average).			Percentage of Total in Bronze and Cupro-nickel.
	Gold and Silver.	Bronze and Cupro-nickel.	Total.	Fuel(Coke).	Crucibles, Muffles, &c.	Total.	Fuel.	Crucibles.	Total.	
	tons.	tons.	tons.	£	£	£	£ s. d.	£ s. d.	£ s. d.	per cent.
1905	386	131	517	561	1,019	1,580	1 1 8	1 19 5	3 1 1	25
1906	630	297	927	837	1,810	2,647	0 18 1	1 19 1	2 17 2	32
1907	921	293	1,214	1,227	2,208	3,435	1 0 3	1 16 4	2 16 7	24
1908	476	501	977	1,081	2,044	3,125	1 2 2	2 1 10	3 4 0	51
1909	523	675	1,198	1,455	2,544	3,999	0 4 4	2 2 5	3 6 9	56
	2,936	1,897	4,833	5,161	9,625	14,786	1 1 4 (Average)	1 19 10 (Average)	3 1 2 Average)	39

COSTS FOR FIVE YEARS (1911–16) WITH GASEOUS FUEL.
(*Fuel and Crucibles.*)

Period (April to March).	Weight of Metal Melted.			Expenditure.			Cost per Ton (Average).			Percentage of Total in Bronze and Cupro-nickel.
	Gold and Silver.	Bronze and Cupro-nickel.	Total.	Gas Fuel.	Crucibles, Muffles, &c.	Total.	Fuel.	Crucibles.	Total.	
	tons.	tons.	tons.	£	£	£	£ s. d.	£ s. d.	£ s. d.	per cent.
1911–12	1,048	445	1,493	1,639	2,767	4,406	1 2 0	1 17 0	2 19 0	30
1912–13	1,030	532	1,562	1,375	2,016	3,391	0 17 8	1 5 10	2 3 6	34
1913–14	828	1,301	2,129	2,307	2,850	5,157	1 1 8	1 6 10	2 8 6	61
1914–15	1,675	673	2,348	2,291	2,971	5,262	0 19 6	1 5 4	2 4 10	29
1915–16	1,790	577	2,367	2,593	2,691	5,284	1 2 0	1 2 8	2 4 8	24
	6,371	3,528	9,899	10,205	13,295	23,500	1 0 7 (Average)	1 6 10 (Average)	2 7 5 (Average)	36

COSTS FOR YEARS 1909 AND 1913.

Year.	Weight of Metal Melted.	Annual Expenditure.				Rate of Cost per Ton Melted.			
		Fuel.	Crucibles, &c.	Wages.	Total.	Fuel.	Crucibles, &c.	Wages.	Total.
	tons.	£	£	£	£	s.	s.	s.	s.
1909	1,198	1,455	2,544	939	4,938	24.3	42.4	15.7	82.4
1913	1,958	2,162	2,613	1,061	5,836	22.1	26.7	10.8	59.6

included in the foregoing tables of costs, as it is considered that sundry minor economies effected under the new system balance this additional outlay.

In connection with the general subject of costs it may be of interest to state the initial outlay made in providing the new buildings with the plant specially required for melting with gas. The cost of the motors and blowers, the four 1,000-light meters, the pipes and connections for the gas and air services and the burners with their accessories was 1,984*l*. The capacity of this melting plant under ordinary conditions is represented by an output of about 2,000 tons annually.

With reference to the foregoing statistics, it may remove possible misapprehension to state that the figures are compiled from the working accounts of the Department, and no allowance has been made for such delays and accidents as have occurred in the routine of work during the periods under review. This feature should be borne in mind in comparing the results shown for the last five years with those of special test runs frequently quoted by furnace manufacturers. In point of fact the weight of the metal which passed through the crucibles is understated in the above returns. No record is made of the weight of the spillings, filings, rough ends, and faulty bars which occur more or less with each pouring, and are remelted in the course of the day's work. The proportion remelted but not noted in the books varies with the several metals and also with the quality of the ingots, but the average weight melted twice on the same day is estimated to be between 2 and 3 per cent. of the total amount given to melt. Therefore, to ascertain more approximately the gross amount melted with the gas recorded at the meters, the weight stated above for 1911–16 should be increased at the rate of (say) 2½ per cent., that is, from 9,899 tons to 10,146 tons.

Recovery of Metal.—An important factor in Mint work is the adequate control of the precious metals given to melt. In an ordinary working day the amount of gold melted is more than 3 tons and is worth nearly 400,000*l*., and of silver about 9 tons, which in coinage value is 80,000*l*. Obviously a satisfactory account of these values must be rendered at the close of the day. And the recovery of the metal given to work was a feature considered in choosing the form of furnace. It was ascertained by experiment that spillings of metal and splashes from the crucible were recoverable with comparative ease from a furnace with a closed bottom, while this form was more uniform in heating results than one with a removable bottom.

Larger deposits of metal in the furnace owing to fractured crucibles were also found to be recoverable. Occasionally a crack develops in the crucible when the metal is molten, and a certain amount runs into the furnace. This metal is allowed to cool after the crucible is drawn, when it forms a solid mass round the graphite stand. It is then possible to chip out the soft plumbago and withdraw the *culot* of metal from the furnace.

The bottom of the furnace consists of a solid fire tile, 20 in. square and 2 in. thick, and at the junction of the lower course of brickwork and the tile a moulding of fireclay is introduced, rounding off the sharp corner. Consequently the spillings and runners on cooling have their under side domed in shape and relieve readily. If the furnace is badly worn and the metal becomes keyed into the side, the lower course of brickwork is removed.

Gold Melting House.—The furnaces for melting gold are similar in construction but of smaller dimensions than those for melting silver and bronze. The room contains 10 furnaces built in a single battery, and the internal measurements of the well-holes are 12 in. in diameter and 21 in. deep. The melting capacity of each furnace is about 17,000 oz., or 529 kg., per working day of 10 hours. As the general arrangements of the plant are similar to those in the larger room it is hardly necessary to specify the details.

The author has to thank Sir Thomas Elliott, the deputy master of the Mint, for permission to communicate this paper to the Institute, and Sir Edward Rigg, the superintendent of the Operative Department, for kindly reading the paper in MS. The drawings and photographs were prepared by the author's colleague, Mr. W. L. Whitaker, to whom his thanks are also due.

CORROSION OF INGOT IRON CONTAINING COBALT, NICKEL, COPPER.—We have several times referred to the researches on cobalt and its alloys conducted at Queen's University, Kingston, Ontario, on behalf of the Department of Mines, by Dr. H. T. Kalmus and his collaborators. This series of researches has also been extended to an investigation of the effects of small percentages of cobalt, nickel and copper on the corrosion of American ingot iron, in particular iron prepared in the open hearth for sheet roofing. It was noticed in 1912 that small amounts of cobalt and nickel made the iron exposed on the roof of the college building more resistant. Further exposure tests were then made and also accelerated tests conducted by immersing the iron in dilute sulphuric acid for an hour and by alternatingly submitting it to the influence of the acid and of the atmosphere. The general results, presented to the American Institute of Chemical Engineers in January, 1917, are favourable. Additions of Co, Ni, Cu, in percentages ranging from 0.25 to 3 per cent., seemed to make the iron, which contained 0.01 per cent. of carbon, darker in colour, more tenacious and uniform and more able to resist atmospheric influences, the corrosion being only about 50 or 75 per cent. of that of the pure iron. Cobalt and nickel seemed to be equally advantageous, but the self-protective coating formed on the rusting iron in the case of the cobalt alloy appeared to adhere better than the coating of the nickel alloy. Copper prevented corrosion in percentages up to 0.75; little was gained by using greater amounts of copper, and it also looked doubtful whether the addition of more than 0.6 or 1 per cent. of cobalt was advantageous; both these percentages seemed to keep corrosion down most effectually.

COLONIAL AND FOREIGN ENGINEERING PROJECTS.

WE give below a few data on several Colonial and foreign engineering projects, taken from the *Board of Trade Journal*. Further information on these projects can be obtained from the Commercial Intelligence Branch, Board of Trade, 73, Basinghall-street, London, E.C.

South Africa.—With reference to the proposed water and irrigation works in Cape Town, it is announced in the *Official Gazette* of the Province of the Cape of Good Hope that the voters of the city were to be asked to sanction the raising of a sum of 268,000*l*. for defraying the cost of the following:—(*a*) The provision of a new reservoir of 200,000,000 gallons capacity in the Silvermyn Valley in the Muizenberg Mountains, by the construction of a concrete dam; the cost of this work is estimated at 205,000*l*. (*b*) The provision of a line of 12-in. cast-iron pipes between Muizenberg and Newlands, at an estimated cost of 35,000*l*. (*c*) Certain investigations in regard to water supply, at an estimated cost of 15,000*l*. (*d*) The provision of buildings, fittings, cleaning, drying and curing areas, water, drainage, sanitary conveniences, &c., required at the new fishing harbour, at an estimated cost of 13,000*l*.

Australia.—The *Queensland Government Gazette* publishes a notice by the Mackay Harbour Board to the effect that the Board proposes to borrow 15,000*l*. to construct the necessary works for the improvement of the Pioneer River, in accordance with the scheme of the Engineer for Harbours and Rivers, Queensland.

China (*Manchuria*).—H.M. Consul at Dairen writes, under date January 10, that two locomotives for the French Indo-China Government railways were recently built at the South Manchuria Railway Company's works near Dairen. A copy of the specification of these locomotives, which Mr. Parlett has forwarded, may be inspected by British firms interested at the Department of Commercial Intelligence.

Argentina.—With reference to the projected sanitation and water supply works at the National Tuberculosis Sanatorium at Santa Maria, Province of Córdoba, it is notified that the *Boletin Oficial*, Buenos Aires, publishes a Decree approving an *ad referendum* contract entered into between the "Comisión Asesora de Asilos y Hospitales Regionales" and the firm of Garbagnati, Angeleri y Jacuzzi, under which the latter will carry out the works mentioned for the sum of about 11,200*l*. A period of nine months will be allowed for the completion of the works.

Chile.—The *Diaro Oficial*, Santiago, notifies that the Chilean Senate has approved a concession granted by the municipality of Santiago to Señores Eujenio Guzman Montt and Gino Girardi for the construction and working of a tramway (animal traction) between the Avenida las Quintas and the Calle de Bilbao, in the city of Santiago.

THE NITROGEN INDUSTRY IN SWEDEN.—The fact that the import of artificial manures has been greatly jeopardised by the war has increased the interest taken in the new Swedish nitrogen industry, which has started on the West Coast. The original company has now increased its capital to 8,000,000 kronor, with an option of a further increase to 24,000,000 kronor, and manufacture on a large scale is understood to be impending. The method of production is stated to be entirely different from the Norwegian method, as practised by the Norsk Hydro Company. The furnaces of the Swedish company gave a good deal of trouble at the start, and comprehensive experiments were necessary to arrive at satisfactory results, which, however, are now said to have been obtained; there have also been difficulties with regard to raw materials. The furnaces are planned in sets of four, and efforts are now being centred upon getting one set finished, and four such sets are contemplated. It has, however, been stated that three furnaces would suffice for Sweden's requirements. Sulphate of ammonium will be the primary product, but the working programme also comprises the manufacture of nitrates on a large scale.

BLAST-FURNACE GAS CLEANING.—The electric treatment of waste gases and fumes is decidedly gaining adherents in the United States. Discussing the question: "Dry-Hot *versus* Cold-Wet Blast-Furnace Gas Cleaning," in the February Bulletin of the American Institute of Mining Engineers, Messrs. L. Bradley, H. D. Egbert and W. W. Strong sum up in favour of the former treatment with respect to the economy of using the gas in hot-blast stoves and under boilers. They rely largely on the data on specific heats of Kuzell and Wigton and on a communication by W. Mathesius, "High-Blast Heats in Mesaba Practice;" these communications were published in the Transactions of the same Institute, 1914 and 1915. The cold-wet scrubbing of the top gas from blast-furnaces, it is pointed out, removes part of the moisture from that gas; at the same time the temperature of the gas is very much lowered, the flame temperature is likewise lowered, therefore, and heat is lost. The electric treatment of the hot gases cleans the blast-furnace gas almost completely, leaves a high temperature, admits of easy recovery of valuable products (metals, potash, &c.), keeps boilers and stoves cleaner, and prevents trouble from slow ignition and imperfect combustion. It is also said that cold-washing of the gas requires large and expensive installations and gives troublesome amounts of muddy water. Nothing is said about the expense of the electric precipitation.